Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JULY 1954

VOLUME • 37 NUMBER 7

starch for paper

plus the help of NATIONAL paper specialists

pulp to packaging

NATIONAL has a completely staffed laboratory devoted exclusively to paper service problems. We are starch specialists. Our research laboratory is constantly exploring ways to derive new paper-making products from starch by truly chemical means: the introduction of new chemical groups or radicals into the starch molecule. Many NATIONAL developments are now in highly successful use in the paper field.

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☐ **CATO STARCH,** a new headbox additive, is based on a cationic derivative, with high affinity for cellulose fibers. It improves the strength factors of paper, such as mullen, pick, fold and tensile. It gives excellent retention of fillers and pigments. Improves formation and finish. Frequently permits increased speeds without loss of strength.

☐ **HYDROSEAL,** a dry beater additive that simulates the gelatinous substance formed by pulp hydration. A cold-water-swelling additive that often permits reduced beater time. No special preparation or expensive cooking equipment necessary. It improves mullen, pick, fold, finish and formation.

☐ **OXIDIZED STARCHES** of various viscosities with exceptional stability, excellent color, high strength for tub and calender sizing.

☐ **HOOSIER CORN STARCH,** a thick cooking, pearl corn starch for beater sizing.

☐ **HOOSIER PEARL CORN STARCH** pH, ideal for enzyme conversion for tub sizings, or other enzyme applications.

☐ **CARBOXYMETHYL STARCH** (CM) is sodium salts of carboxymethyl ethers of starch for use in calender sizing to improve gloss ink printability. Applications also in tub sizing and specialty coatings.

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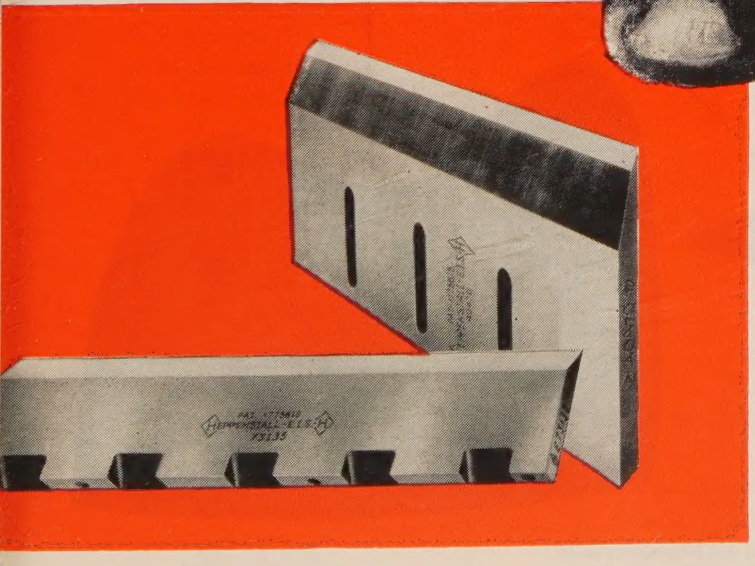

Many leading pulp mills make Heppenstall their standard specification for chipper knives. Heppenstall's record for durability provides such production advantages as:

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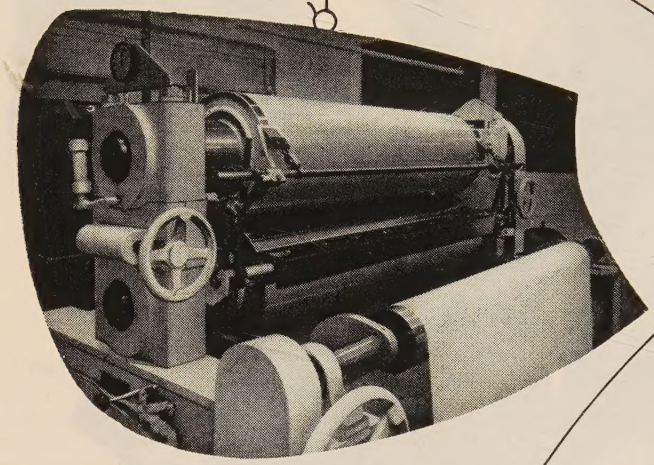

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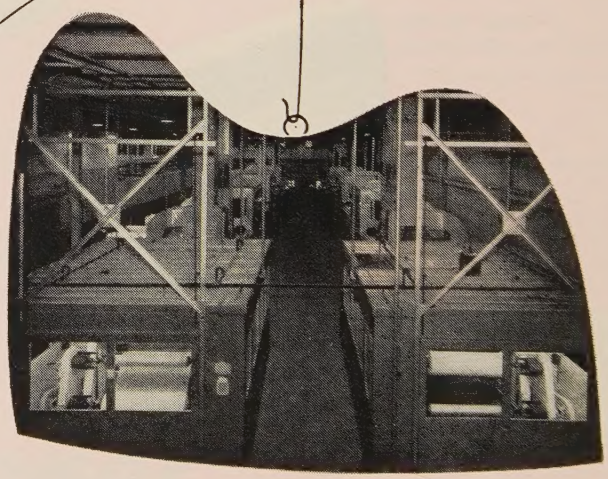

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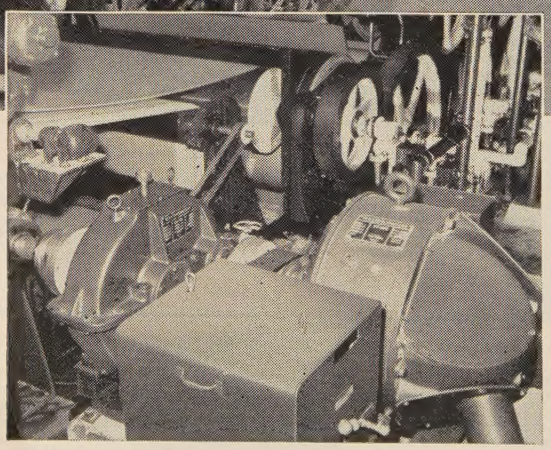
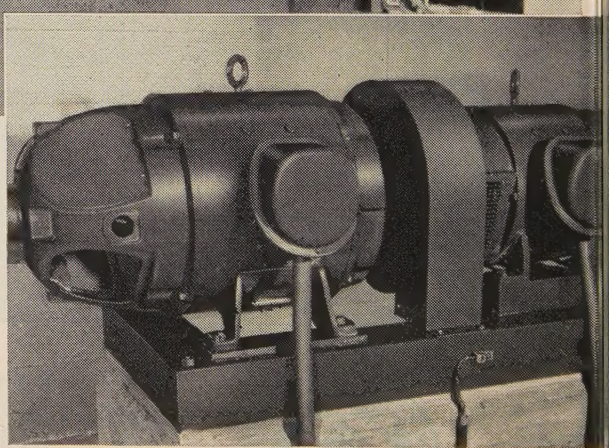
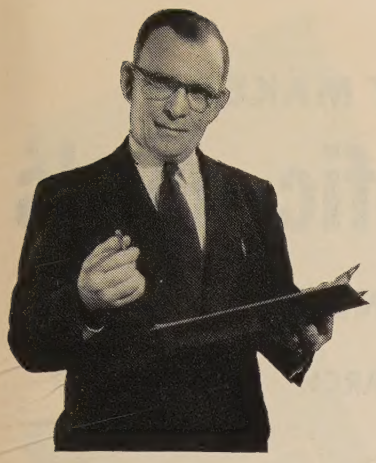
Magamp control used with differential regulator maintains the proper speed on each section under practically all conditions. It does this regardless of changes in load, variations in vacuum, changes in nip pressure and doctor blade pressures.



D-c motor coupled to reduction gear unit—here's a typical section driving unit. Totally-enclosed and force-ventilated, the unit is, in turn, coupled to the paper machine's press section.



Master frequency m-g set supplies an adjustable frequency reference to the individual section speed regulators for securing any operating speed. Flywheel compensates for inertia differences.



Westinghouse drives with Magamp boosted our paper production

Paper machines vary in size, type and number of sections, operating speed range, width of sheet and type of paper produced. In every case, the drive must be engineered to meet these variable factors. After asking you, the papermaker, what you needed most in a drive, Westinghouse modernized its sectional motor drive to give you minimum down time, peak production, and less maintenance.

Westinghouse Magamp (Magnetic Amplifier) regulator—a unit that precisely controls section speeds and draws—permits high operating speeds without paper breaks. It's a static device with no tubes and no moving parts other than the cone pulleys and reference motor. Magamp is more rugged, reliable, and requires less maintenance than any other type of regulator now on the market. Elimination of line shafting, with its associated belts, pulleys and clutches, is a safety factor and a space saver. Magamp regulated drive cuts outage time and operating costs. Initial base adjustments, once made, remain unchanged during the equipment's life.

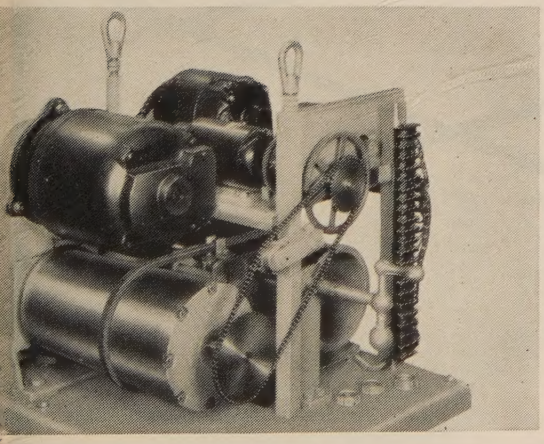
Every Westinghouse paper machine drive is an engineered application. Each unit of apparatus is selected to meet job requirements and specific mill conditions. The heavy, rolled steel frame of the Type SK d-c motor, with uniform magnetic qualities, makes it possible to duplicate speed characteristics accurately. Form-wound armature coils, cast brass brushholders, separate field coil units, deep commutator segments, and either sleeve or antifriction bearings provide maximum life and dependability.

Gear units and gearmotors are designed and built by Westinghouse to give you dependable and economical power transmission. Motor speeds are reduced to the roll speeds of each driven section by efficient, single helical gears and tapered roller or ball bearings. The exclusive Westinghouse B. P. T. taper-hardened process is used on all gears and pinions. Horizontal split-case construction makes all parts easily accessible for quick, simple inspection without disconnecting couplings, draining the oil, or dismantling the drive.

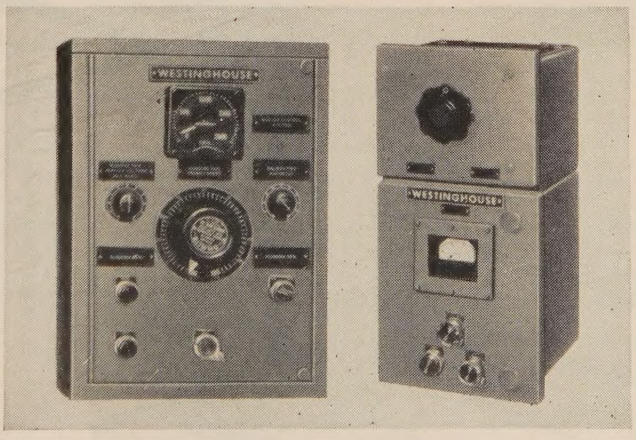
MP-3039

YOU CAN BE **SURE**... IF IT'S

Westinghouse



Error detecting unit compares the individual section speed with the master set frequency. Any difference is transmitted to the Magamp regulator which brings the section speed in step.



Operator's master control station (left) shows speed indicator and provides for automatic control of machine functions. An individual operator's station (right) has a meter to show load.

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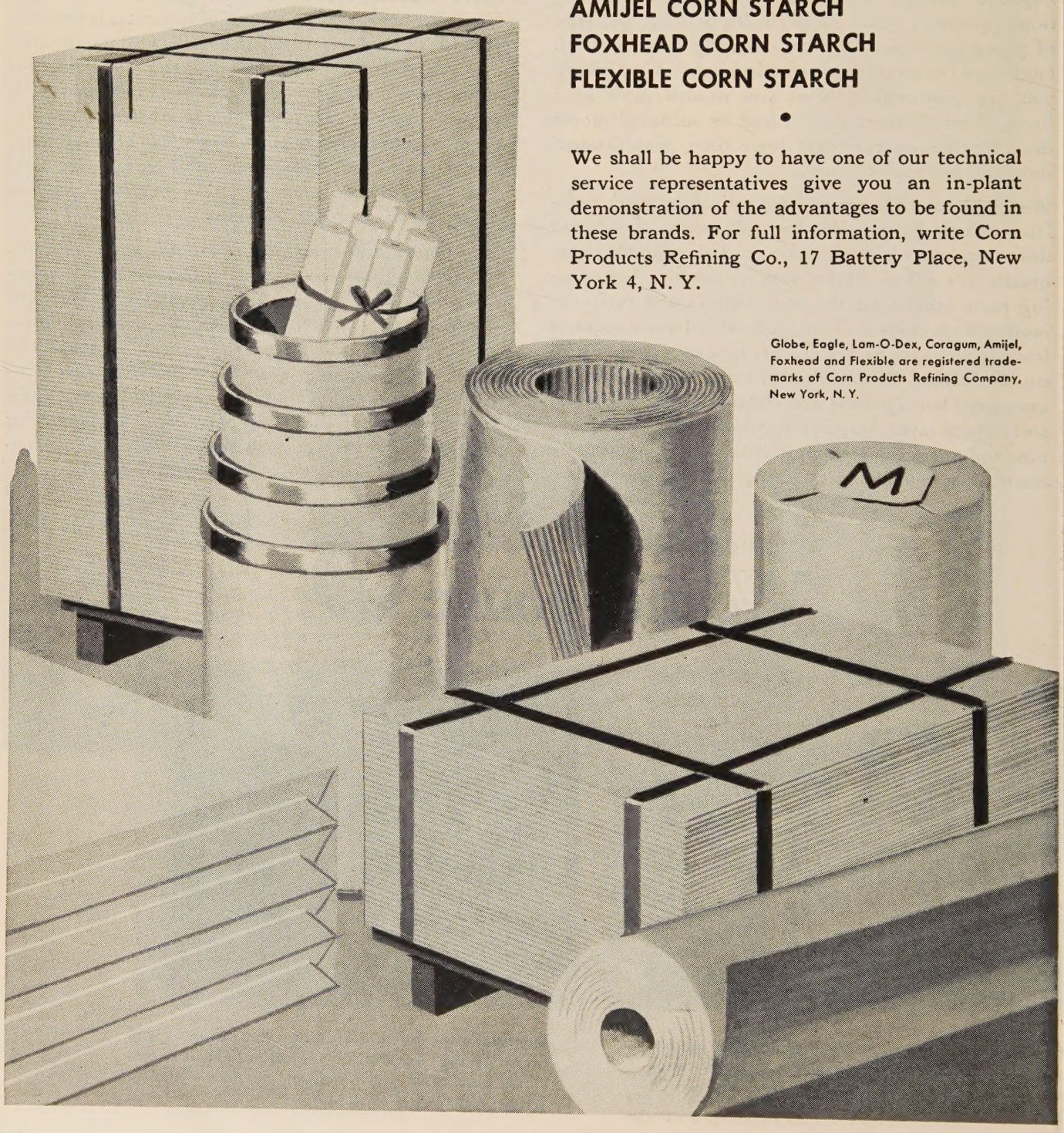

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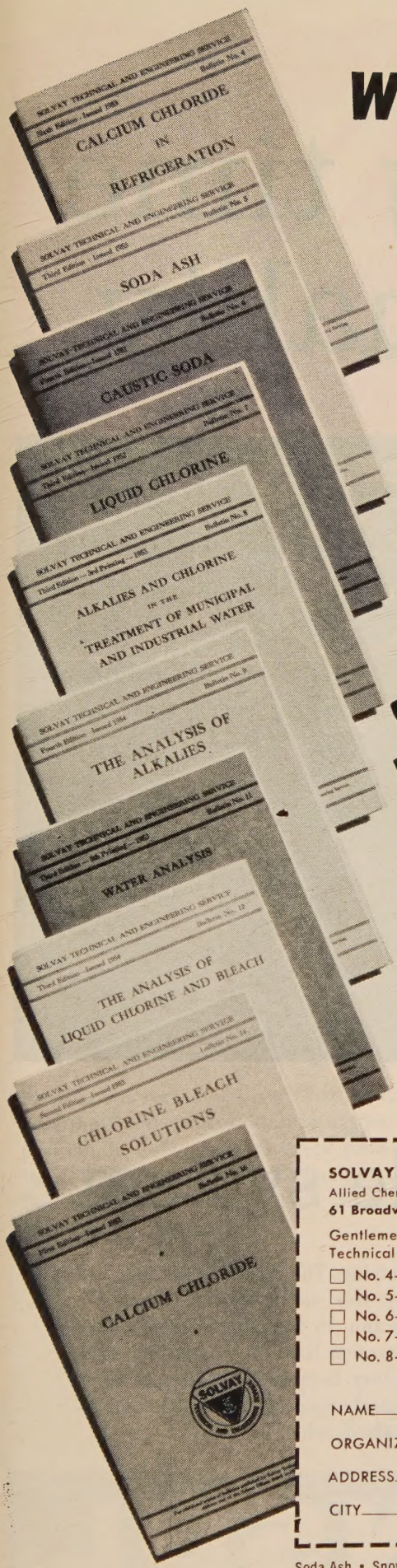

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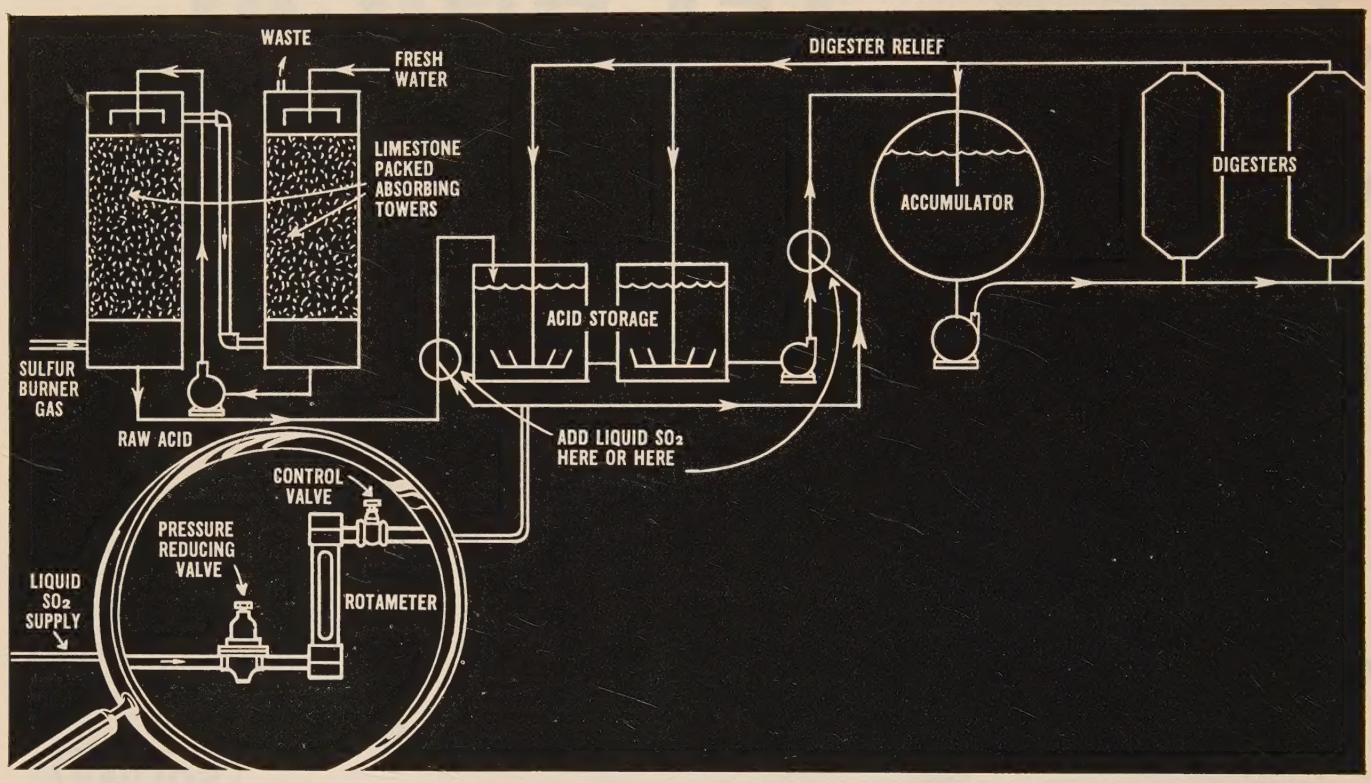

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Installing an Ansul sulfur dioxide system is the sure, economical way to cut cooking time and keep sulfite pulp production going at an even rate *in spite of* wet or green wood cooks, high water temperatures or other hard-to-control variables.

Adding free sulfur dioxide to the acid supply gives faster wood chip penetration thereby increasing the rate of pulping. The increased pulping rate gained by adding free sulfur dioxide permits a considerable reduction in the pulping temperature for a constant digestion time. This cuts fuel costs and increases quality because lower temperatures give higher yields and improved chemical and physical properties to the finished product.

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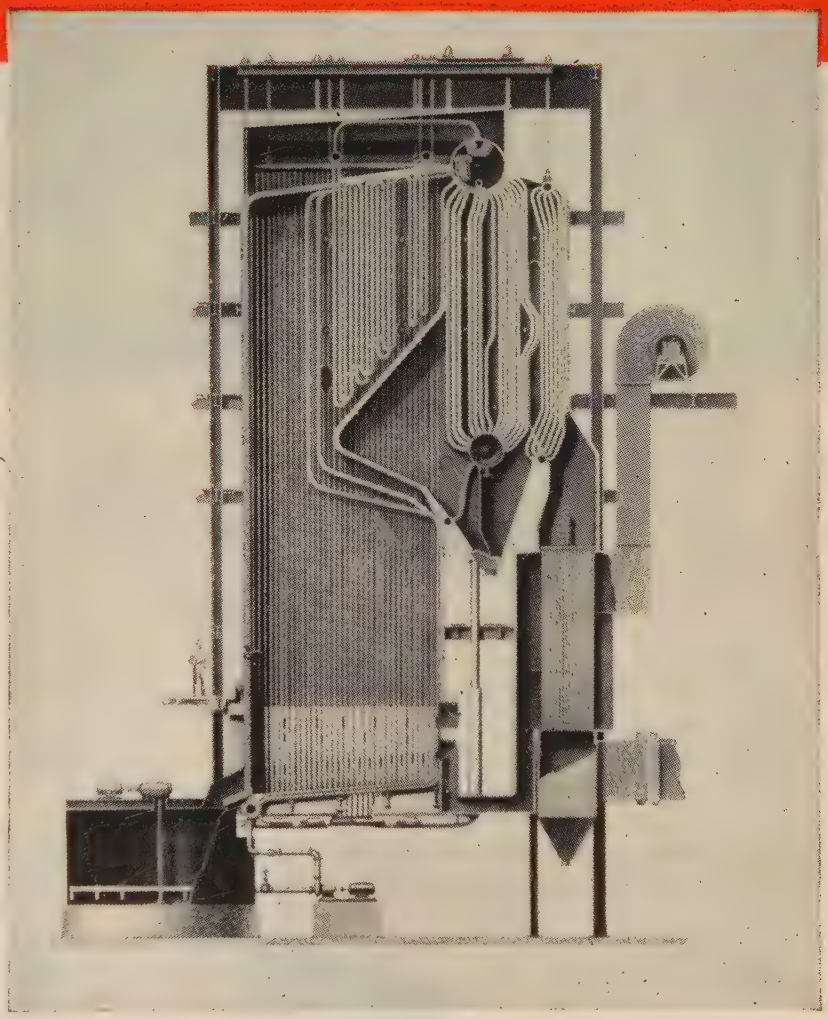
The performance record of B&W installations such as those at Charleston puts the B&W organization in a good position to solve your recovery problems. The Babcock & Wilcox Company, Boiler Division, 161 E. 42nd Street, New York 17, N. Y.



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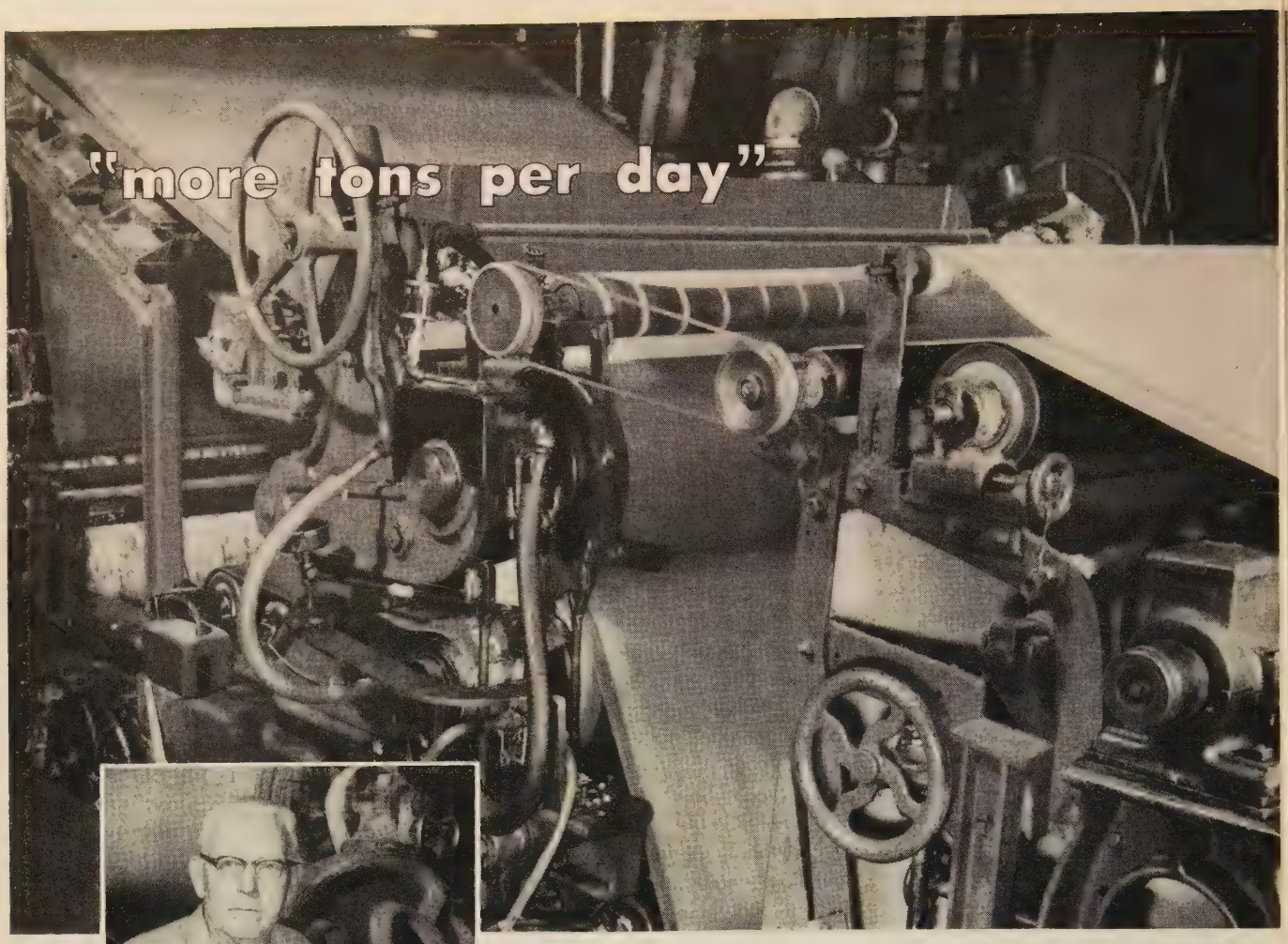
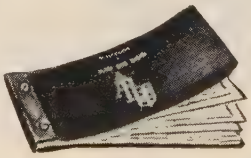


STEVENS & THOMPSON PAPER COMPANY, Greenwich, New York, produces tissue, toweling and napkin on six machines. For over 35 years they have used Albany Felts on their single-cylinder tissue machines. Charles Howland (left), Mill Superintendent, reports "more tons per day" with Albany Felts.

Albany Felt Company's technically trained sales engineers constantly strive to improve felt performance on your machines. Just as twenty-five years ago Albany engineers introduced the revolutionary concept of individually designed, custom-made felts for each felt position, today they are supplementing this valuable service with actual operational studies which we term "felt performance check." This extra service, by analyzing the basic principles of felt operation in relationship to over-all efficiency assures our customers MORE TONS PER DAY. Even more important, Albany sales engineers are backed up by the industry's leading service engineers and felt makers, a complete service laboratory, an extensive research and development program, and a product *famous* for quality.



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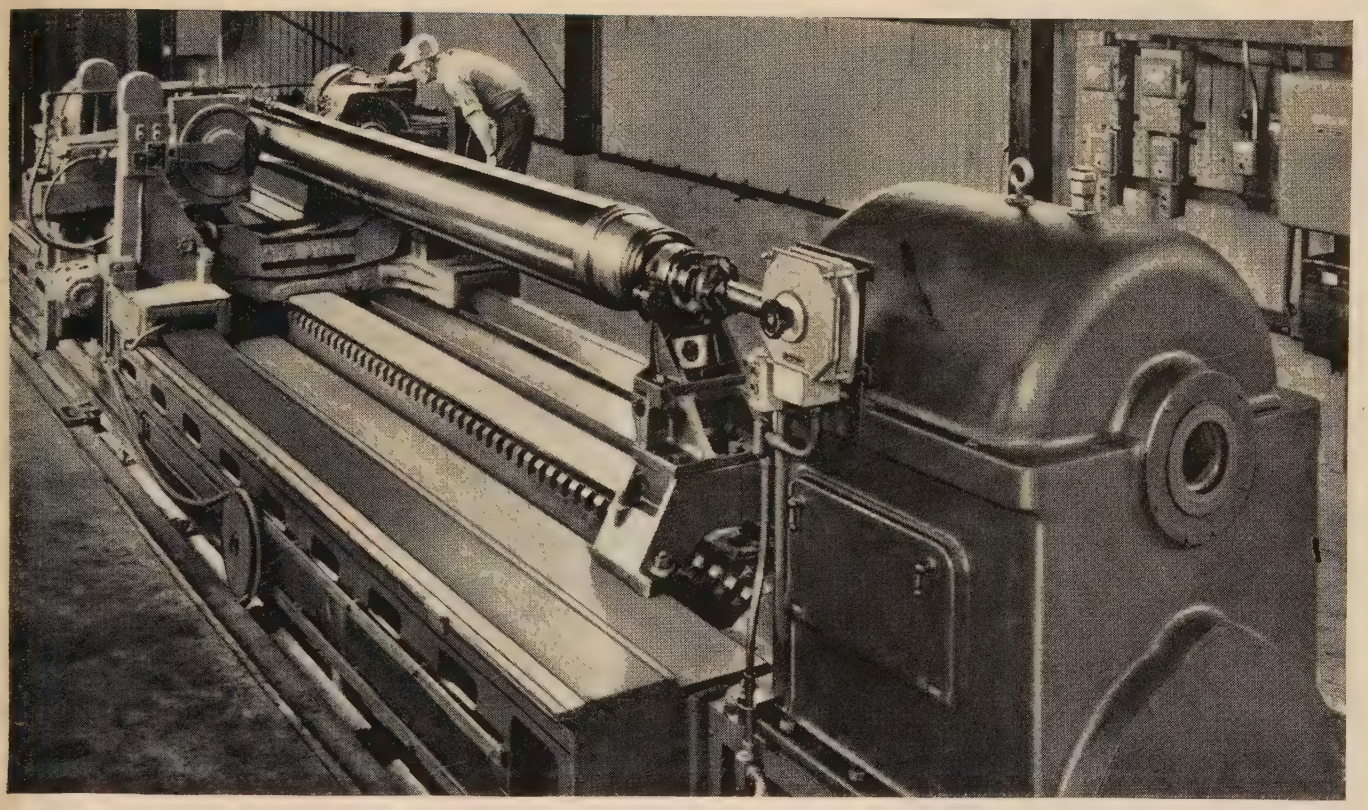

When you grind a roll with a Farrel® two-wheel, swing-rest roll grinder, you get that extra accuracy you need for highest quality production.

The swing-rest method of mounting the grinding wheels offsets any effect on roll accuracy which might be caused by the ways being slightly out of parallel as a result of distortions in the machine bed from seasoning, temperature changes, settling of foundation, etc.

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These and other features of the Farrel two-wheel, swing-rest roll grinder permit definite standards of accuracy to be specified and reproduced on any number of rolls.

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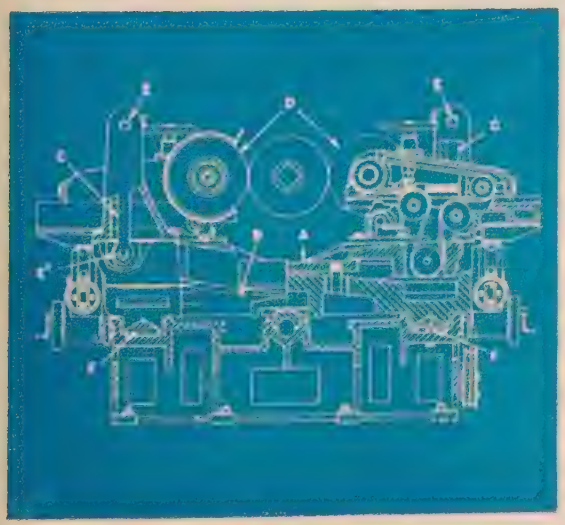

THE SWING-REST PRINCIPLE

The diagram shows how the two grinding wheels are mounted in a Farrel swing-rest roll grinder.

The saddle "A" is swung by links "C" on knife edges "E" and "E1" from brackets supported on carriage "B". The grinding wheels "D" are mounted on the saddle.

Any movement of the carriage "B" imparted by inaccuracies in the ways "F" will cause a corresponding sidewise movement of the saddle supports. If the grinder were operated as a fixed-wheel machine, this would also cause an equal sidewise movement of the grinding wheels.

But in the Farrel swing-rest machine, instead of following the path of the ways, the grinding wheels follow a line parallel to the axis of the roll. Hence, the error transmitted to the roll is reduced correspondingly.

Farrel-Birmingham®

The Paper Industry—1954

LOUIS T. STEVENSON

Our forecast of last Fall has proved accurate by the actual developments in paper production in 1953 and so far as this first quarter of 1954 is concerned. The stability of the paper industry in periods of recession is again being demonstrated. With an over-all drop of 10% in the F. R. B. Index of Industrial Production its component index "paper and board production" has dropped only 4% from the peak of 1953. The average production for the first quarter of this year is only 2% below the record 1953 average. Paper production is up about 2%, newsprint up 5%, while paperboard production is down about 5%, building paper and board about 4%. Paper manufacturing 1954 profits, before taxes, seem assured at about the 1953 levels. Paperboard companies' average profits before taxes are expected to be lower because a lower average production ratio is expected to prevail than in 1953. The profit pattern for paperboard is expected to be somewhat mixed depending on individual companies' situations including their "product mix" but on the average, paperboard profits are expected to be lower. The passing of the excess profits tax is expected to increase the net after taxes for a number of paper and board companies. By and large, it is impossible to generalize further, because of the variations in the "product mix" of the major producers.

THE 1954 FORECAST

LAST November in our publication "Outlook for the United States Paper Industry in 1954," we concluded that production for 1953 and 1954 would be as follows:

	1953		1954	
	Production, million of tons	*Ratio to capacity, %*	*Production, million of tons*	*Ratio to capacity, %*
Paper, ex-newsprint and building paper	10.2	93.5	10.6	96
Paperboard	12.5	92	11.6	83
Newsprint	1.1	96	1.2	92
Building paper and board	2.9	96	2.6	87
Totals	26.7	93 av.	26.0	89

The questions arise: (1) How nearly right have these forecasts proved to be up to the present? (2) Have the prospects changed for 1954? If so, in what respect?

The previous estimates for 1953 were prepared in early November and were based on nine months' census data. These predictions should have been quite close to the actual developments. The following table compares the estimates with the tonnage produced.

The deviations from the estimates were small.

The current production can be broadly indicated by the two published weekly production ratios. These give current indications of the tempo of activity in the two largest segments of the industry—paper and paperboard. The paper production ratio does not include newsprint or building papers and the paperboard ratio includes no building board. The paper ratio is a "per cent of normal tonnage capacity." The paperboard ratio is "per cent of operation based on inch-hours reported on a 6-day basis.

	1953	
	Estimates	*Production*[a]
	Millions of tons	
Paper, ex-newsprint and building paper	10.2	10.328
Paperboard	12.5	12.488
Newsprint	1.1	1.066
Building paper and board	2.8	2.739
Total	26.6	26.621

[a] Source, A. P. & P. A. monthly Statistical Summary, December, 1953.

There are differences between these ratios and the ratios shown in our November 18 forecast. The capacity used in that was a "6-day week, tonnage capacity."

The actual ratios published for the year 1954 through January, February, and March are—

American Paper and Pulp Association (Paper)....	94.1%
National Paperboard Association (Paperboard)...	89.0%

Revision of the A. P. & P. A. paper index to the same basis as used in our November 18 forecast would give the following comparison between our prediction and the results for the first quarter:

	3 Months' results, %	*Forecast for year 1954, %*
Paper	99	96
Paperboard	89	83

In each case the results for the first quarter have been above our percentage forecast for the entire year.

This is not confirmed by the volume of production in the first quarter of this year. Production estimates now available indicate that over-all production was practically identical with the corresponding quarter of 1953. The drop in the building grades and paperboard was about 5% while the major paper groups were higher than last year. Based on the daily average tonnage produced in these three months, the over-all production this year could reach 26,100,000 tons, or just about our forecast of 1954 volume. This is the rate for the first three months and does not necessarily indicate what the final actual volume will be this year. This aspect will now be discussed and somewhat at length.

THE CURRENT OUTLOOK

What is to come in the last three quarters? Broadly speaking, changes in the consumption of paper de-

LOUIS T. STEVENSON, Economist, Tucker, Anthony & Co., New York, N. Y.
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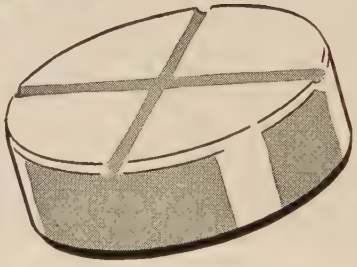
Note: Sources for Chart data are— Figs. 1 to 5: American Paper and Pulp Association; Figs. 6 to 10: National Paperboard Association.

Vanzyme discs



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pend upon general business conditions. Paper cannot pull itself up by its bootstraps in a broad recession. But this industry is widely diversified and flexible, serving the entire consuming public in many ways. High growth rates in per capita consumption have characterized most of its products. Some of the grades have grown faster than others. Some fluctuate more widely than others but the historic record indicates a higher rate of growth for the paper industry than for that of the economy as a whole, taking the gross national product in constant dollars as an indicator. As a consequence, over-all paper production has never in recorded statistics returned to a former low.

A RECESSION

The adjusted Federal Reserve Board's index of industrial production reached a peak in May, 1953, and the preliminary March, 1954, index of 123 was about 10% below that peak. We are undoubtedly in a recession from that peak, with durable goods down 14% and nondurable goods down 8%. The latter index has remained steady at 113 for the 3 months ended with March of this year.

These facts require a more detailed analysis, and this will be attempted.

SOME BASIC DATA ON THE PAPER INDUSTRY

In the following pages will be shown in chart form some of the available basic data on the paper industry with respect to orders, shipments, production, and order backlogs. Other pertinent information will be shown and an attempt will be made to draw the whole picture together to a conclusion on the prospects for the industry over the balance of the year.

Measurements of Supply and Demand. The accompanying chart (Fig. 1) shows one of the rather generally

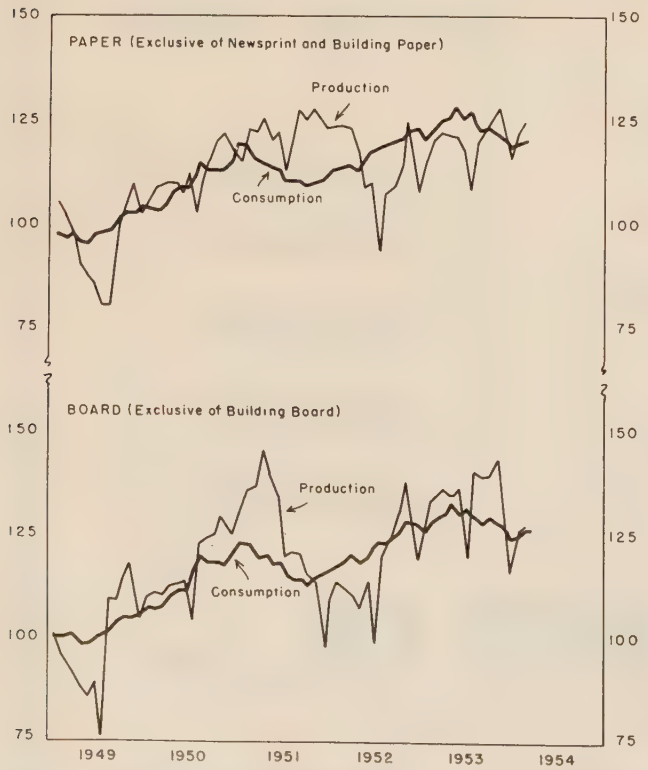


Fig. 1. Paper and board production and consumption (1947–1949 = 100)

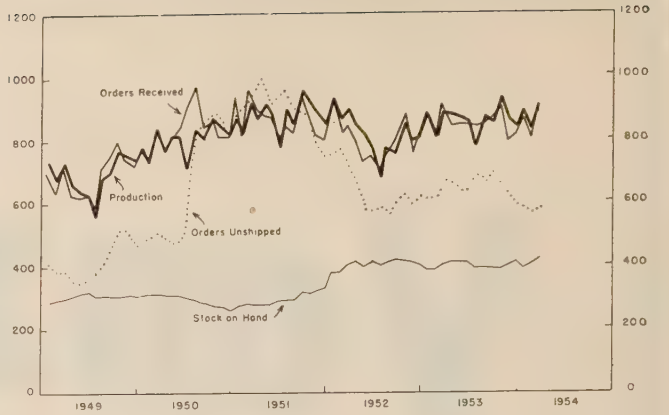


Fig. 2. Paper exclusive of newsprint and building paper (thousands of tons)

accepted broad indexes of supply and demand: Production and consumption for the two major segments of the industry. These are "paper, after excluding newsprint and building paper" and "paperboard, excluding building board."

In the paper chart it will be noted that since the Spring of 1952, the *consumption* index has generally been above the *production* index. Thus inventories in the paper group are relatively low.

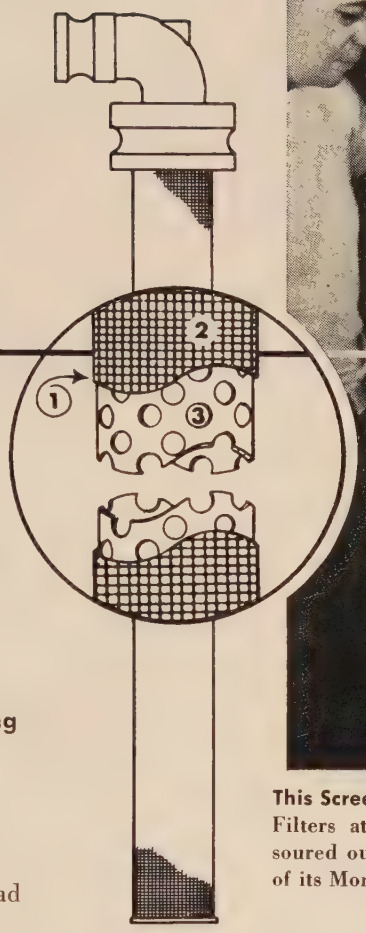
The paperboard chart shows quite a different picture. In the Spring of 1952, paperboard was going through a serious inventory correction from the peak production and inventory building that had occurred in the latter half of 1950 and most of 1951. The recession apparently "overcorrected" the previous expansion and when the turn came in August of 1952 as a result of an increase in *consumption*, paperboard *production* almost literally jumped above the *consumption* line and there it has remained steadily except in the seasonally low months of December and July.

The recession in business, commencing in 1953, has brought these consumption indexes down by about 6% below the May, 1953, peaks.

From this analysis, it is but logical to expect an *increase* in paper production and a *drop-off* in paperboard production in the current year as a correction to the overproduction since the August, 1952, rebound and as a result of the drop in consumption incident to the current recession. In the face of this expected drop in paperboard volume a sizable increase in capacity to produce paperboard is coming into production this year. However, the analysis of the effects should not be made upon the paper and paperboard industry as a whole. The industry should be broken down into its segments to determine the probable effects. This will be done after examining the available data on orders, production, shipment, and stocks on hand at the mills.

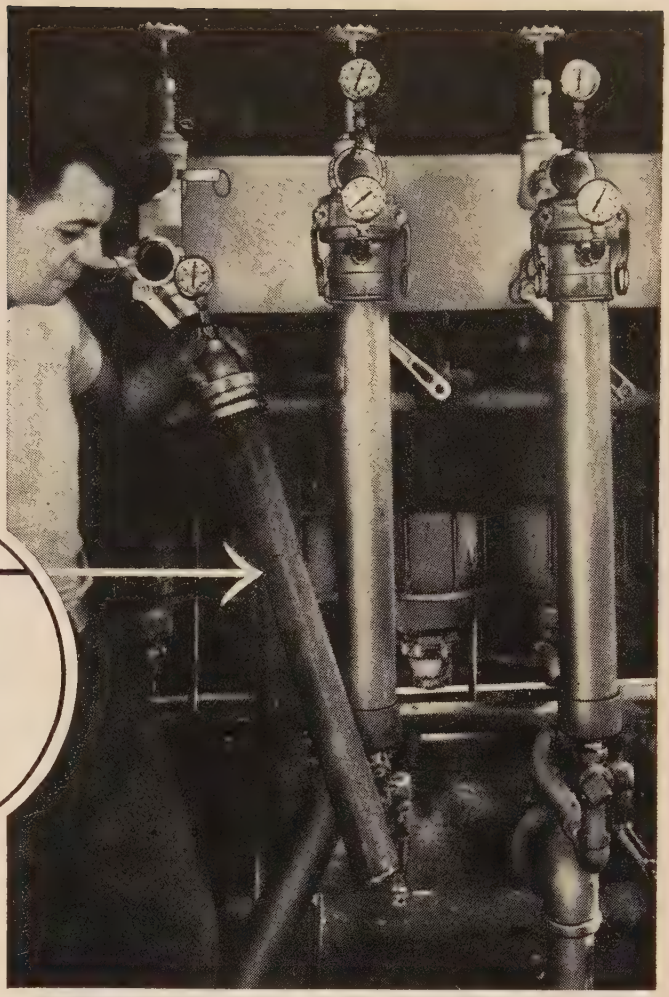
The Paper and Paperboard Charts. Figure 2 shows the order situation and mill stocks for the major paper group which includes all paper grades excepting newsprint and building papers. Figures 3, 4, and 5 show subgroups of this broad group and Figs. 6 to 10 cover the paperboard industry except the building board grades. Each of these charts will be briefly discussed. One point should be kept clearly in mind: The "stock on hand" shown on the figures is mill stocks only. These vary from time to time, but they are, generally speaking, but a small part of the available supply.

How well do your fluid filters stand the —STRAIN?



Important Features of the Ronningen Screening Element

1. Direction of flow is inward
2. Corrosion-resisting Monel screen, welded at both ends
3. Perforated Monel inner backing



This Screening Element from one of the 35 Ronningen-Petter Fluid Filters at Allied Paper Mills, Kalamazoo, Mich., has just been soured out with dilute muriatic acid. Note the excellent condition of its Monel mesh.

Fluid filters handling white water lead a hard life. And often a short one.

There's no denying, of course, that white water is *corrosive*. Or that grit, forced through the screen under pressure, is *wearing*.

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Monel resists corrosion and pitting by paper stocks and white waters. It can be safely soured out in dilute solutions of muriatic acid.

Monel is tough, too. It withstands wear and abrasion caused by particles forced against the mesh at pressures up to 150 pounds. Screens don't clog. Perforations remain smooth. With Monel helping out, you can see why your filters not only last longer and require less maintenance, but why they also *work* better.

Another advantage: Monel presents no problems to the experienced fabricator. For example, the fine mesh Monel screening of the Ronningen-Petter Fluid Filter illustrated on this page, is welded. No internal gaskets needed at either end. No end leaks possible because of poor-fitting gaskets. And as Monel is easily silver soldered, the replacement of mesh is a relatively simple job.

The Ronningen Fluid Filter removes dirt, scale, solids and sand from water, chemicals, oils, and other liquids — hot or cold. Use it for the prevention of plugging in shower nozzles and foam killer sprays . . . for the protection of valves, pumps, meters and other equipment . . . for raw water primary filtering and for fine polishing filters.

If you've been having trouble with filters, it will be worth your while to get all the facts. Write the Ronningen-Petter Co., Dept. M, Vicksburg, Michigan, and ask for a descriptive folder. In addition to their own products, by the way, Ronningen-Petter is also a distributor for the Brown-Singer Company, makers of Monel fluid circulating systems, and Monel save-all pans and trays.

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The largest stocks are in the hands of distributors and consumers. Generally speaking, mill stocks represent considerably less than a month's production. They are generally kept for the purpose of servicing customers without resorting to small uneconomic mill runs. These stocks normally run relatively high for fine papers with their many lines of colors while they are relatively low in the printing grades.

Figure 2, Paper. In this chart the broad movements are visible. The low order backlog and production in 1949, the rise in orders from the recession low, followed by the pickup in production are all shown. Production and order backlogs remained stable until the middle of 1950 when the fighting in Korea started. Then orders and backlogs jumped, with orders pushing production and reaching a peak in July, 1951. The backlog tapered off to a low in May, 1952, followed by production which was again forced upward by a rise in orders and backlogs. It should be noted that although mill stocks have grown somewhat above their '50 and '51 "shortage" low, the order backlog at the end of '53 was quite substantial, and by no means comparable with the low 1949 backlog. That is the over-all picture for the major paper group. Let us now examine its components.

Figure 3, Fine Paper. The fine paper group includes writing papers, bristols, cover papers, thin papers, cigarette, and other fine papers. The fine paper group has felt the impact of war conditions more than any of the other parts of the paper group. This is clear from Fig. 3. With order backlogs low in 1949, stocks at the mills were not high. Orders pushed up normally in the first half of 1950 and "went boom" when Korea started. Mill stocks were depleted while production grew, forced by high order backlogs. These dropped in the latter half of 1951 and were followed down by production in the second quarter of 1952. Recovery of order backlogs and increases of mill stocks brought relatively stable production in 1953, at a level lower than the Korean boom. The year ended with a seasonal drop-off in the order backlog, but picked up sharply in the first quarter of 1954.

Figure 4, Printing Papers. This classification, shown in Fig. 4, includes book and similar papers, groundwood printing and similar papers, and machine-coated printing papers. Large volumes of magazine, catalog, circular, and other printing papers are included in this broad category.

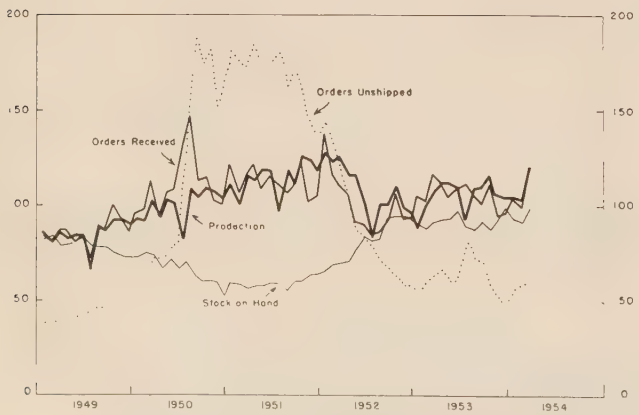


Fig. 3. Fine paper (thousands of tons)

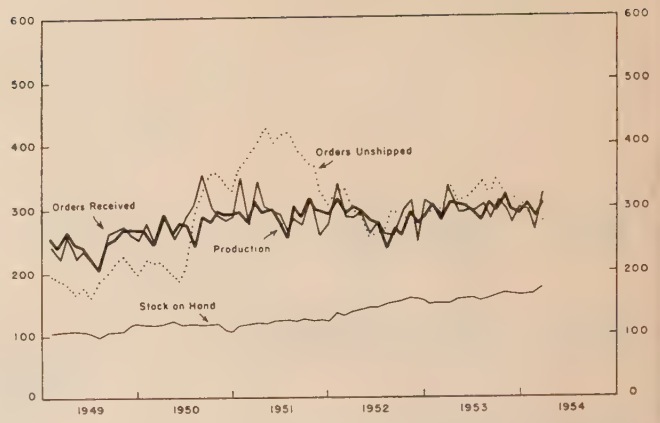


Fig. 4. Printing paper exclusive of newsprint (thousands of tons)

The picture shown by the chart is one of steady and gradually increasing production. Order backlogs were healthy when Korea boomed them upward. They have reached a peak in 1951 and are now 50% higher than early 1950. Mill stocks have been slowly rising so that they now represent about fourteen to sixteen days' operation. Altogether it is quite a strong picture at the beginning of 1954.

Figure 5, Coarse Paper. This segment includes unbleached kraft papers, sulphite wrapping and similar grades, butchers wrapping, some bleached kraft grades, waxing papers and glassine, greaseproof and vegetable parchment papers. Speaking broadly, they are the wrapping, packaging, bag, and shipping sack papers.

Production of these grades as shown by the chart has experienced two recessions in the last five years, one in 1949 and one in 1952, each following drops in order backlogs. These have followed a somewhat similar pattern to that of the fine paper group but with more moderate swings. The backlog was adequate in early 1950 to assure high production before Korea boomed "orders unshipped." Production was raised by capacity increases and then fell off in the second quarter of 1952, from which it recovered to a peak for the year of over 300,000 tons in October of 1953 and a steady first quarter in 1954.

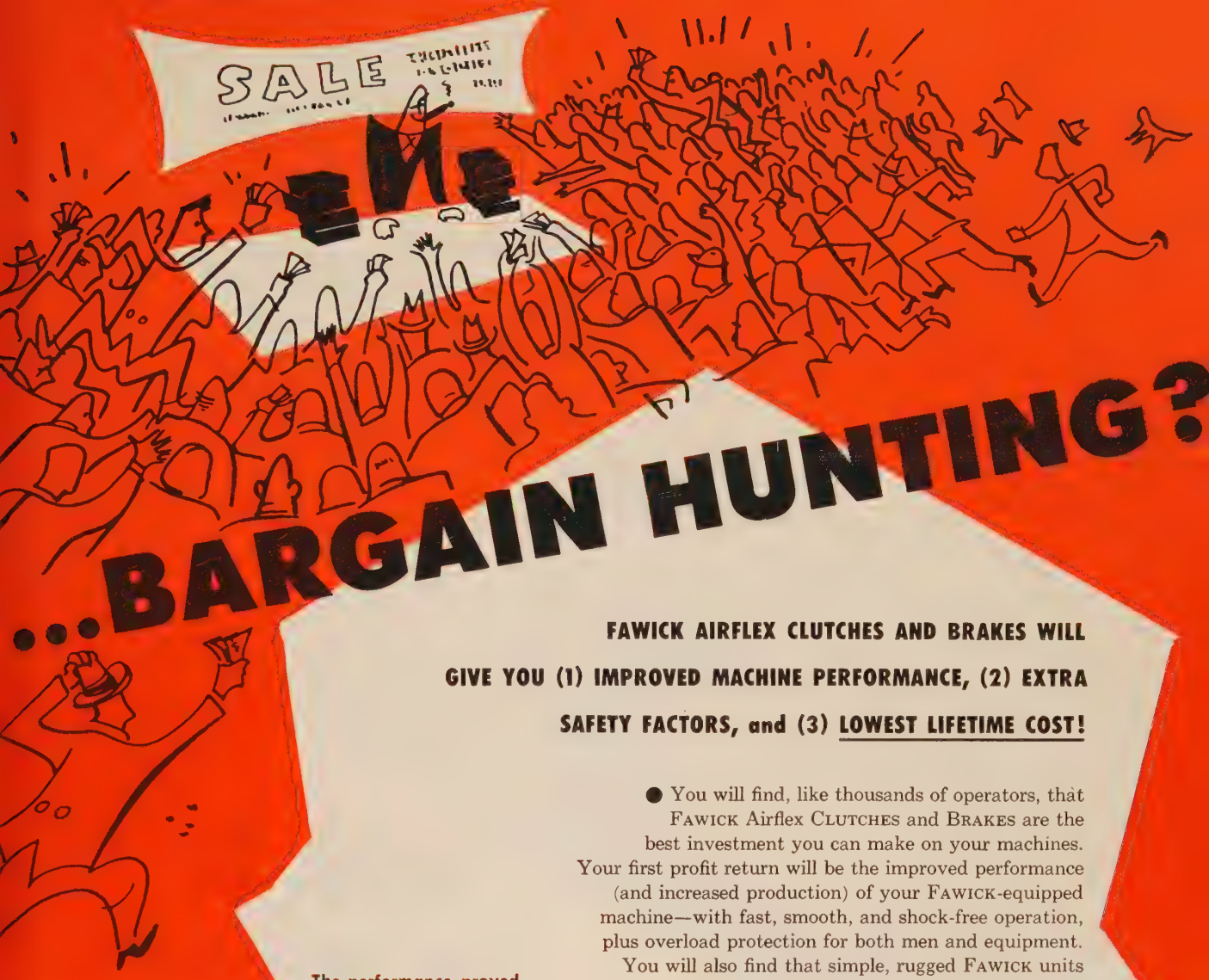
Summary for the Paper Grades. The strong position of these grades is shown in Fig. 1 "Production and Consumption." The production index has been below the consumption index almost continuously since March, 1952. The consumption index reached a peak in March and a low in December, 1953. These indexes show slight increases in January and February, 1954, with the latter about 6% below the May peak.

The rather long period in which production has been below consumption puts this part of the industry in an exceptionally strong position with customers' inventories well down. This is confirmed by the relatively high backlog of orders shown in Fig. 2.

Turning to the main segments of this group, Fig. 3 shows that fine papers have returned to about a normal peacetime position after the Korean episode which created a major disturbance in their normal behavior.

Figure 4 shows the printing paper group to be exceptionally strong with order backlogs high, and steady production. The 1952 drop is barely noticeable.

In Fig. 5, coarse paper is running slightly below the



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1951 peak with order backlogs below the Korean peak level but still well above the 1949 low.

The conclusion is that the printing papers are in strong position, with the fine papers and coarse paper groups returning to normal peacetime behavior. The combined consumption of these grades has exceeded the combined production and therefore the over-all position of the group appears to be strong at the start of 1954. The behavior of the nondurable goods index in January and February indicates a leveling off in the paper consumption index which, if it develops, will assure high production in the major paper grades.

Some companies operating in these grades are:

Fine Papers:
Champion Paper & Fibre Co.
Crown Zellerbach Corp.
Eastern Corp.
Hammermill Paper Co.
International Paper Co.
Mead Corp.
West Virginia Pulp & Paper Co.

Printing Papers:
Champion Paper Co.
Crown Zellerbach Corp.
International Paper Co.
Kimberly-Clark Corp.
Mead Corp.
St. Regis Paper Co.
West Virginia Pulp & Paper

Coarse Papers:
Champion Paper Co.
Crown Zellerbach Corp.
Gaylord Container Corp.
International Paper Co.
St. Regis Paper Co.
Union Bag & Paper Corp.

Tissue Papers. These grades have not been presented separately in the charts although they are important segments of the paper group shown in Figs. 1 and 2. Only production data are available for these grades which include wrapping tissue, toilet and facial tissue, cellulose wadding, paper toweling, and napkin stocks.

As one of the fastest growing segments of the paper industry, it is almost certain that the major companies in this field are enjoying good business.

Among the companies in this group are:

Crown Zellerbach Corp.
Kimberly-Clark Corp.
Marathon Corp.
Scott Paper Co.

Figure 6, Paperboard. In this chart will be seen the climb of production in response to a sharp increase in orders, from the recession low of 1949, when the order backlog got down to 240,000 tons. Production and orders then remained in balance until the "Korean boom" started in July, 1950. The resulting high backlog of orders continued until early 1951 when orders tapered off, followed by production. The backlog of orders hit bottom by the end of 1951 and held steady until the last half of 1952 when orders and production rose to higher levels. These continued through to a peak in the Fall of 1953, after which production and order backlogs dropped to a year-end low with an upswing in the first quarter of 1954.

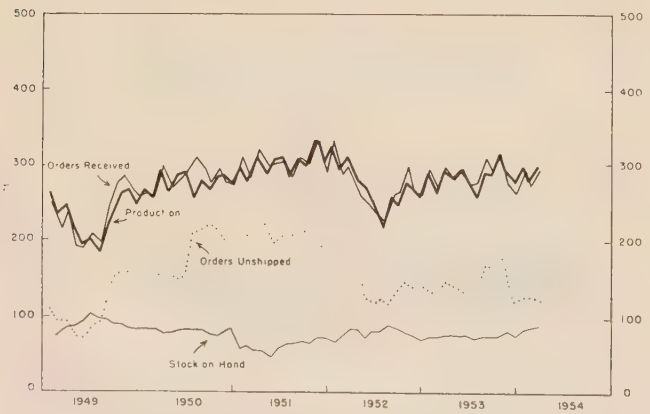

Fig. 5. Coarse paper (thousands of tons)

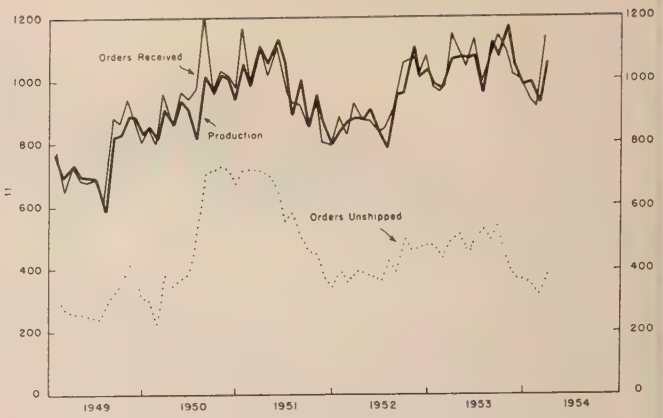

Fig. 6. Paperboard exclusive of building board (thousands of tons)

This chart shows the broad picture of the paperboard industry with the only published data on orders, production, and shipments. To differentiate among the components of the paperboard group, a discussion of the trends and other factors will be necessary.

Container Board. In Fig. 7 is shown the production for this grade from 1935 to 1953 inclusive. The pronounced upward slant indicates a rapid growth. Two main subdivisions of containerboard result from the analysis of the group by the raw materials used to make the board. Figure 7 shows this breakdown by "wood pulp" or kraft and semichemical container, and "other," principally jute liner and chip solid fiber and chip and straw corrugating medium which will be called "jute" in this analysis. The sharp increase in kraft grades and the relatively static position of "all others" is apparent from Fig. 7. Kraft has been growing steadily while jute has taken the brunt of the slumps. The reason for this lies, at least in part, in the 30% weight-strength advantage in favor of kraft.* It seems logical to expect that tonnagewise the jute containerboard will bear the brunt of a dropoff of production in containerboard.

Folding and Setup Boxboards. Figure 10 shows production of folding boxboard to be a growing segment. The raw materials and equipment used are somewhat similar to those in making jute containerboard and there has been a tendency for "jute" mills to go into folding boxboard as a relief from the pressure of kraft competition. The fast-growing food board is shown in Fig. 9. Setup boxboard suffered a setback during World War II from which it has been recovering slowly. As shown in Fig. 8, it has in recent years about recovered to the peak established by it in 1941.

* Gates, J. E., "The Kraft-Jute Containerboard Controversy," *Fibre Containers and Paperboard Mills*, Chicago, January, 1954, p. 46.

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Conclusion with Respect to Paperboard. In spite of the favorable showing of paperboard production in the past quarter, it is believed that the paperboard production total will drop in 1954 to the level forecast in our Nov. 18, 1953, "Prospects for 1954" study.

This analysis indicates that with respect to tonnage growth the most favored groups of paperboard mills will be: (1) manufacturers of food board, (2) manufacturers of folding boxboard, (3) container board manufacturers in the kraft semichem. group, and (4) makers of setup boxboards.

Of these, the high growth rate of food board is expected to continue and will absorb such new capacity as is expected in this grade.

Folding boxboard will have a normal increase in tonnage but the 1953 capacity will be increased by shifts from jute container board production.

In container board the "jute" grades are expected to take the brunt of the drop in tonnage while the kraft grades retain present tonnage. Increase in kraft and semichemical containerboard capacity will speed the lowering of the operating ratio in this containerboard.

Makers of setup boxboard are expected to drop some tonnage from the volume made in 1953 if the historical pattern is followed.

Companies making food board include:

Champion Paper & Fibre Co.
Crown Zellerbach Corp.
International Paper Co.
Marathon Corp.
Sutherland Paper Co.
West Virginia Pulp & Paper Co.
Weyerhaeuser Timber Co.

Manufacturers of folding boxboard include:

Continental Can Co.
Container Corp.
Robert Gair Co.
Hinde & Dauch—Div. of West Virginia Pulp & Paper Co.
International Paper Co.
National Container Corp.
Sutherland Paper Co.
United Board & Carton Corp.

Companies making container board in the kraft or semichemical wood pulp grades include:

Container Corp.*
Chesapeake Corp.
Robert Gair Co.*
Gaylor Container Corp.
International Paper Co.
Mead Corp.
National Container Corp.
St. Regis Paper Co.
Union Bag & Paper Corp.
West Virginia Pulp & Paper Co.*

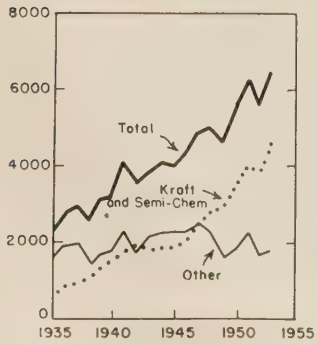


Fig. 7. Containerboard

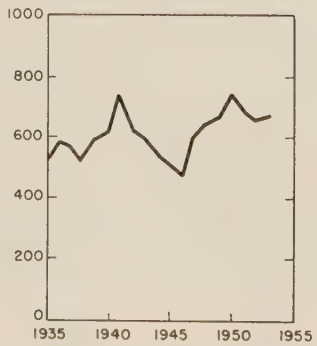


Fig. 8. Setup boxboard

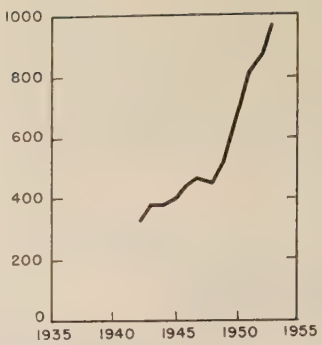


Fig. 9. Special food board

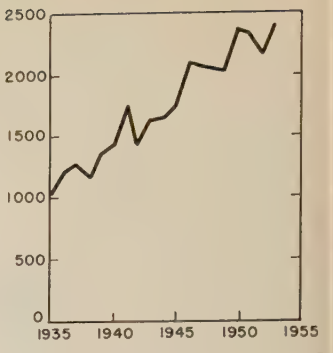


Fig. 10. Folding boxboard

Makers of setup boxboards include:

Container Corp.
Robert Gair Co.
United Board & Carton Corp.

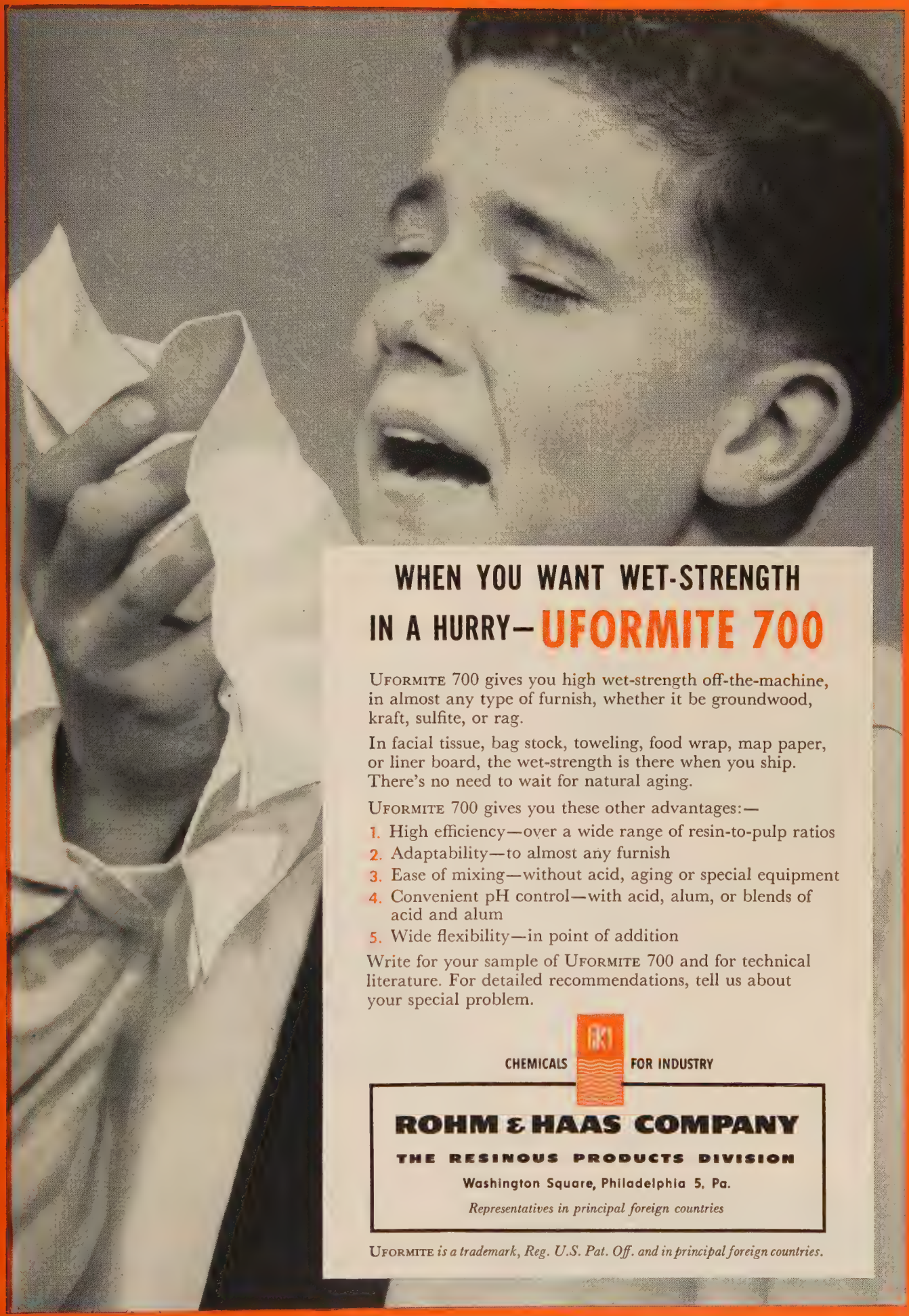
GENERAL CONCLUSIONS

In spite of a drop of 14% in durable goods production and an 8% drop in nondurables from the 1953 peaks, the paper and paperboard industry has operated at a high tonnage level in the first quarter of 1954, almost equal to the industry average in the record year of 1953. Both the paper and paperboard operating ratios have in the first quarter exceeded our November, 1953, forecast, with the paper ratio running above paperboard by almost 10 percentage points. It looks as if the recession has about leveled off, judging by the behavior of the consumption indexes and the nondurable goods production index, which has an important bearing upon paper production. If such proves to be the case, the paper industry could exceed last year's over-all tonnage production. Production ratios, because of the heavy increases in capacity in kraft and semichemical paperboard, are liable to be lower in paperboard than last year and also lower in paperboard than in paper for 1954.

Paperboard manufacturers have an enviable record for the development of new applications of their product and, under the spur of heavy competition, could find higher employment for their increased capacity than would be indicated by normal projections of past behavior. The first quarter indicates that this might be the case this year, although an average production ratio of 90% of capacity for the full year would be about the top limit.

A high rate of operations in the paper segment is indicated with special emphasis on the sanitary and printing papers. The fine and coarse paper groups have returned to about normal peacetime rates of operation. By and large, the current recession has hurt the industry very little and indications are for a good, but competitive, year in 1954. Present indications are that our November, 1953, forecast was close but that with respect to the paperboard group, in particular its expansive nature in the face of competitive conditions, it may have been underestimated. Undoubtedly the "antidepression" moves of the government and the Federal Reserve Board have been helpful. There is a prospect that the paper industry will have another good year in 1954.

* Also makes jute container board.



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EARNINGS

Earnings before taxes have in the past fluctuated with production ratios. With lower production ratios in the paperboard group, earnings before taxes are expected to be lower for those companies that operate in that segment of the industry, with the qualification that the jute container board mills are expected to bear the brunt of the effect.

As will be noticed from the above listings of companies, many operate in the several segments, and there is scarcely any clear-cut identification of individual companies with particular segments of the paperboard field. Most of the companies listed operate in several segments.

Integration with converting operations also affects individual company earnings. The National Paperboard Association reports that in 1952, 66% of the mills making folding boxboard owned box plants which consumed 50% or more of the parent companies' production. The percentage for containerboard was about 50%.

Because of these variations among the companies, it is difficult to generalize about earnings in the industry and individual analyses would be necessary to evaluate earnings prospects by company.

In general, however, mills operating in the paperboard field are not expected to have as good earnings before taxes, compared with 1953, as those making the paper grades. In many cases the drops in earnings will be offset by the elimination of the excess profits tax.

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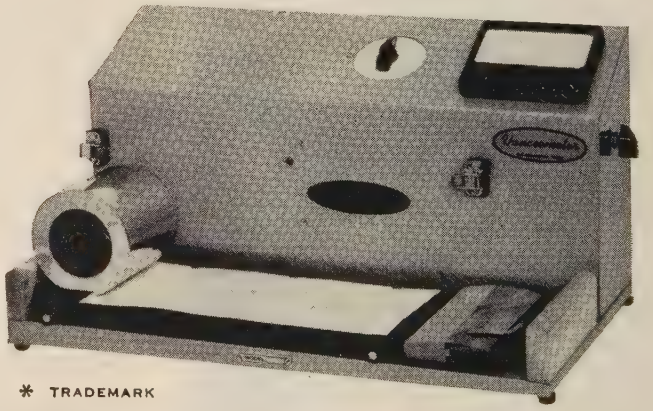

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Fact-Finding

REX. W. HOVEY

At the start, I would like to offer my congratulations to you men, as members of the Technical Association, for the many contributions that you have made to the coated paper industry as it stands today, and I sincerely believe that much of the future progress in the manufacture of coated papers will result from your research and development work.

Since we are meeting in the State of Maine, and since quite a number of you come from other parts of the country, I think it might be appropriate to take a moment to give you some idea of the position of the State of Maine in this industry in relationship to the nationwide industry.

In 1952 the State of Maine produced in excess of 1,300,000 tons of woodpulp, which is 8% of the national total, with only the States of Washington, Florida, and Louisana producing more pulp.

Maine produced in 1952 1,331,000 tons of paper which is 12% of the national total, and in 1952, 190,000 tons of machine coated papers which is 17% of the national total.

Of the approximately 20 million acres of land in Maine, about 17 million, or 84% are in timber and woodlots.

It is estimated that over a quarter of a billion dollars is invested in the Maine paper and pulp industry, with over 100 million dollars having been invested since the end of the war in new facilities, equipment, and modernization.

In the State of Maine there are over 19,000 pulp and paper mill workers employed in this industry, and the workers and their dependents total some 76,000 people. The 29 pulp and paper manufacturing establishments in Maine are located in 24 different communities. From these figures it is evident that not only is the pulp and paper industry important to Maine, but the pulp and paper produced in this State is a significant part of the national total.

As a background for our discussion this evening of some phases of research in our industry, I think it is worth while for us to examine some facts which illuminate the prospects for the future. Looking ahead for the long term, recognizing that there will be short term economic adjustments, I believe that our industry will go through a period of growth which staggers the imagination.

One of the strongest forces making for good business in this country in the years ahead will be the tremendous increase in population. In 1952 the United States population was 158 million, in 1960 it will be 180 million and in 1975 it will probably be between 220 and 225 million. In 1952 there were 46 million households in the United States and this will become 52 million in 1960, 57 million in 1965, and 67 million in 1974. From 1965 to 1974 new households will be formed at the rate of over 1 million a year, entirely comparable to the high rate of household formation obtained in the years just after the war. The formation of these new households and the growth in population will create a tremendous market for products of this industry and will also create a great opportunity to you to meet these requirements.

Supplementing the terrific importance of the increase in population is the expansion in the usage of paper per capita in the United States through the development of new papers and paper products for an ever-expanding range of end-uses. Competition creates advertising in all of its forms. The best educated population on earth will continue to expand its reading of magazines, books, and advertising.

Meeting the challenge of the increased demand for paper for the long term will involve many complex technicological problems and it is appropriate that in the meeting here tonight we discuss the use of some of the tools that will be used in accepting the challenge of growth and utilization of paper and paper products.

Many of you in this room have been in the coated paper field long enough to have seen, as I have, the radical transition from the days when coating formulas were closely held secrets involving many rule-of-thumb practices to the current stage where the production of various coated papers at very high speeds involves the most complete coordination of the best thinking of the papermaker, the research man, and the engineer. This progress can only have been based on technical developments which have resulted from "fact-finding". I want to deal with some of the elements of "fact-finding," and I would like to bring to your attention a number of research tools and other considerations that contribute to a well-rounded research project. In many cases, I would like to bring these points to your attention through raising questions.

Do you realize the importance of market research at the start of a significant research project? Before you undertake the development of a new product, have you carried out the market research to determine the size of the market, its location, the competition existing in that field, and many other significant considerations? As the research work progresses, have you gone back and made rechecks of the market situation, because they have possibly shifted during the time that the research work has been underway. The paper industry, as it grows in volume and diversification, is using market research more and more, and I believe it should be recognized by you men as being a valuable research tool.

As you undertake a research project, have you made a careful literature survey to assemble known and published information on the subject under study? Any modern research laboratory must of necessity have an adequate technical library to avoid duplication of work and to make available to the research scientist literature on past work on a given subject.

As you undertake the production and the research

Rex W. Hovey, Executive Vice-President, Oxford Paper Co., New York, N. Y.

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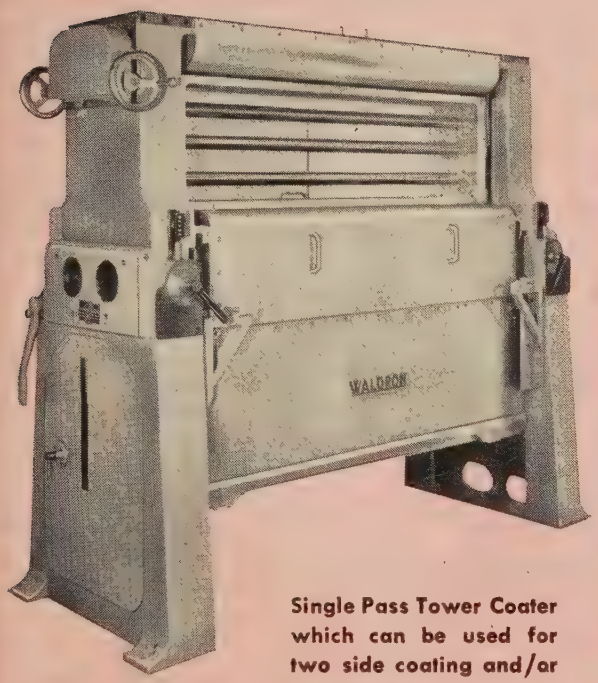

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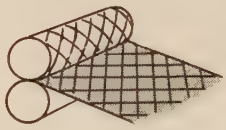

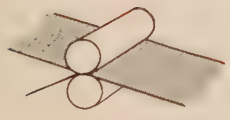

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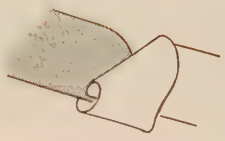

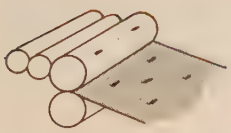

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work on a new grade of paper, have you assembled all of the known information on its end-use requirements? Are your facts limited to current end-use requirements, or do they also include a look into the future? If you are developing a new printing paper, have you given consideration to new developments in printing presses and printing inks that may in the future affect paper requirements?

It is obvious that machine time is costly. It is equally obvious that for the development of new grades and new products, machine time must be set aside for commercial trial runs. Do you recognize the importance of pilot operations to develop in the laboratory on a pilot scale the know-how to put a new grade on the paper machine with minimum expensive complications? Have you considered the value of pilot operations for the training of men who will be able to carry the know-how into operations? Have you realized the value of pilot operations for the production of sample quantities for market end-use evaluations?

As the facts are developed, as the research program goes along, are you using modern statistical analysis techniques to arrive at sound conclusions from the facts available? As the research project was set up, was it designed in such a manner as to make the use of this statistical analysis tool most effective?

In modern paper coating, the operations are at such high speeds that many of the conditions are not observable and it leads to conjecture as to what is happening. Have you given careful consideration to the use of high-speed photography as a research tool to stop the motion and to have photographs available of the conditions under observation to convert from conjecture to fact?

Another valuable source of facts and information as background for your research and development work is your sales-service department. As the printing and conversion of paper has become more technical, various companies have developed competent sales-service organizations with informed people being in the field of these printing plants and conversion plants, and it has been found from experience that these sales-service people can turn into their organization many important facts which should be recognized by the research people and used as a basis of many of their considerations.

Recognizing the shortage of technical man power and yet having many problems poured into the research funnel, it should be mentioned that a common practice in meeting this situation is the use of non-technical assistants to work along with the technical men, under proper supervision from qualified technical personnel. These nontechnical assistants are productive and effective.

Surely one responsibility of a research department is to supply trained man power to other phases of the company, for example, technical service, sales-service, and manufacturing. I think it will be recognized that the success of many research developments depends on having fully qualified men in the plant to help produce such a product and in the field to help market and service it. Therefore, wherever possible the research leadership should recognize this responsibility so that as men are moved from research into other phases of the company, these shifts can be made without upsetting the research department and the continuity of its program.

I have noticed with considerable interest that two major speeches before TAPPI groups in New York in February both stressed the significance of human relations and human engineering.

The TAPPI Medalist, Gunnar Nicholson, said in his acceptance address in New York in February that one of the most important territories which TAPPI and its membership might well afford to explore more fully is that of human relations. He stated that people represent our most valued resource, and the key to their greater productivity is "work happiness." This work happiness is attained largely through the recognition by management of the dignity of the individual and the importance of the individual job. The development of contented and productive employees is not a Utopian dream and can be accomplished, but the process is necessarily slow and does involve continuous study and training. Mr. Nicholson summarized by saying that in short we must strive to inculcate in each employee a greater understanding and deeper appreciation of his individual importance in the scheme of things.

The President of TAPPI, George H. Pringle, in his address to the TAPPI luncheon in New York in February, stated that one of the most important lessons we have to teach the young graduate is the significance of human engineering. He stressed the fact that the young technical graduate must learn to work with the practical man in order to obtain from him the benefit of his practical background and experience without which no technical training is worth while.

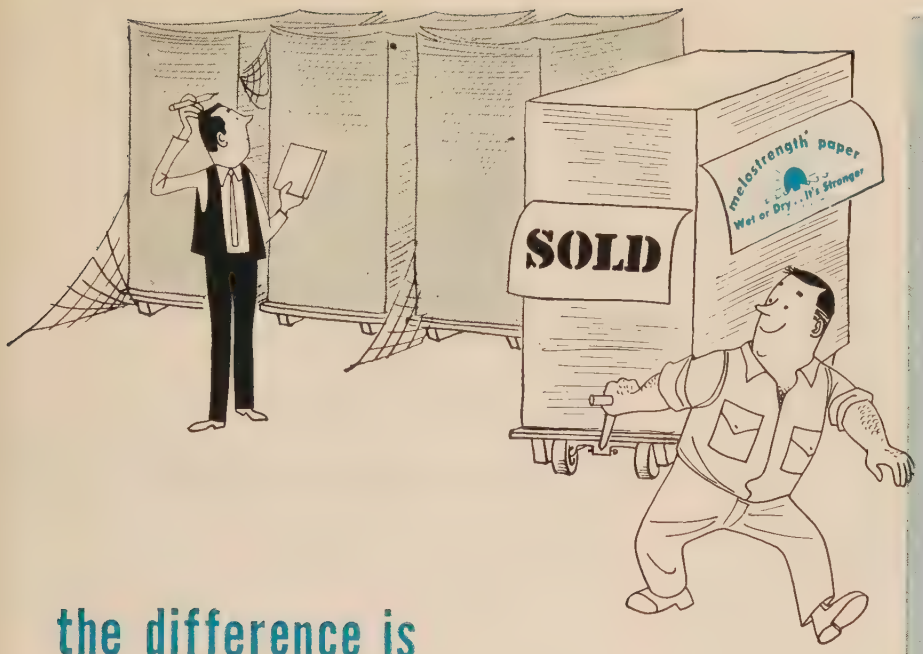
It is quite significant to me that these two industry leaders at the same convention should stress the importance of human engineering and human relations, and I repeat it to you here for emphasis to stress the importance of the skilled laborer and papermaker and his relations with you as the technical man in the industry.

While dealing with the problem of the importance of people, I would like to make reference to the problem of the shortage of technical man power. Every company that has aggressively expanded their research program and organization has come up against this limitation, and it is more and more clear that it is an obligation of the industry to make clear to technical graduates the exceptional opportunities in the pulp and paper industry. People are the most important asset of a research laboratory.

Many companies are progressively getting this gospel across to various educational institutions, and many colleges and universities have given recognition to the pulp and paper industry through planning courses in this field, carrying out research projects for this industry, and enlightening their graduates of the opportunities. One of the outstanding examples lies in this State at the University of Maine.

It seems to me that we must bring these opportunities to the attention of young people, not when they reach the final stages of their college education, but that we must go back even to the period before they enter college.

As is well known this technical man-power shortage is a national problem and affects not only our industry but all industries, which, in turn, means that our in-



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dustry is in competition with the rest of American industry for this limited man-power pool.

I believe it is appropriate to express, on behalf of the paper industry, our appreciation to our suppliers for the valuable technical assistance that they render to this industry. In the old days, the suppliers' representatives were salesmen, but today many of the suppliers have technical service personnel calling on the mills, and these men perform an extremely valuable service in that they are fully informed on the technical aspects of the product that they have to offer and are able to meet with the technical personnel and bring to the paper mill's attention new products that are available with complete technical information as to its properties and the proper way to use it. Behind these technical service people from the companies of our suppliers we find in most cases strong research backing, and any research manager will recognize that a significant part of assembling the facts on a problem is consultation with the technical personnel from his supplier's organization.

Research in pulp and paper has come to a better understanding of what is happening in many processes through the use of some of the newer tools, such as the radioactive tracers, the use of the electron microscope, particularly on particle size problems, the use of a spectrophotometer in measuring small quantities of elements based on the fact that in many delicate situations only small quantities disturb the conditions, and the development of the special devices that measure the rheological properties of coating mixture particularly in machine coating under high shear conditions.

Many research projects fail, or are ineffectively handled, because of the failure of communications within the department or from one department to another. As you start the research project, do you have a clear picture from sales and management as to the nature of the problem? As you complete the project, have you clearly presented your findings in order that management and sales may fully grasp the significance of your research work with respect to sales opportunity and earnings? The research department's findings must be put into use before results are realized and an important factor is the selling of these results through clear presentation.

It is evident that money spent on industrial research is expected to produce a return and these research projects must be considered a business proposition and the basis for tomorrow's profits. Research, by being linked with other phases of the company, strengthens the entire structure.

The position of your company and its profits are closely related to the long term planning for the growth of your company and it is important to have these research programs closely correlated with top level management policy, because such a program is the basis for tomorrow's position. This over-all planning involves sales, manufacturing, engineering, and finance planning along with the research program.

Research is commonly divided into fundamental research and applied research. In the case of applied research, the program is directed toward a definite practical objective, whereas fundamental research is primarily directed at finding the fundamental laws involved. It is evident that the function of the research laboratory is primarily the solution of the problem and that the solution of these problems require "fact-finding." It is from these facts that we have to draw conclusions, which expand our comprehension of the situation, and it is self-evident that there is an overlapping between these two types of research, with such fundamental or theoretical research leading to many practical applications. It was not too many years ago that research people worked essentially alone, but today the trend is toward research team activities. This results partly because the problems have become more complex and partly because the pace of modern business demands more speedy solutions to problems. More and more problems encountered in this industry involve the combined talents of the chemist, the physicist, the engineer, and the papermaker into a team of specialists.

As our wealth of knowledge improves through research, we have a sounder basis on which to undertake further research programs, which is another way of saying that the more research there is, the more research there tends to be.

As our fundamental knowledge increases, as a result of this research, it is reasonable to expect that more problems can be solved successfully at a lower cost in less time.

It has been of interest to me to observe the designing and building of new modern research facilities by various companies in the pulp and paper industry, which is a recognition of the part that research plays in the future of the industry and its earnings. Another trend worthy of note is the integration and centralization of research facilities.

Supplementing the research work being done in the laboratories of pulp and paper companies is the research being carried on on industry-wide basis in such institutions as The Institute of Paper Chemistry. The industry has found from experience that the certain types of problems which require fundamental research can best be handled by such an institution with broad industry support. It is also a common procedure for research organizations to "farm out" certain types of specialized research problems which require special facilities and highly specialized scientists. Using this approach serves the double purpose of having the educational institution more familiar with paper industry problems and bringing to bear on these problems the more fundamental approach that is typically possible in the industrial research laboratory.

It has been a real pleasure for me to have the opportunity to discuss with you briefly this evening a number of phases of research and the manner in which they tie-in with the future of our industry. As we look back, we are proud of the technical progress that has been made, but, as we meet here tonight, it is reasonable to assume that at this time we have merely started on our technical progress, and the technical and development opportunities ahead of us are beyond your imagination. The problems that you are working on daily should be considered by you as a challenge and an opportunity and I wish you all the best of luck in your endeavors to meet this challenge.

Presented at the Fifth Coating Conference of the Technical Association of the Pulp and Paper Industry, Poland Spring, Me., May 24–26, 1954.

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Industrial Management and Human Relations

G. W. E. NICHOLSON

TODAY we are living in a rapidly changing world, and here in America where industry plays such an important part, we are witnessing daily changes not only in manufacturing processes but in management attitudes as well.

Considering the rapid technical progress and the changing conditions in American industry, we are faced with the fact that almost any method or practice used becomes outmoded every 5 years and should be examined carefully periodically for changes which might be required. This certainly is true in the pulp and paper industry which I understand is now the third fastest growing industry in our country.

We must never assume the attitude that we are doing a perfect job. There is always room for improvement. If we become smug and complacent instead of pursuing a dynamic and progressive course, we are going to find ourselves trailing in the competition. There is an axiom that one cannot stand still. He either goes forward or backward. This is true in the case of individuals and it is also true in the case of companies.

The progress in the past has been measured to a large extent by technical developments, and this will undoubtedly continue to be the case to a very great degree. There are, however, other territories that we in management must provide more attention than we have in the past. Much of our future progress will depend upon how well we have learned, and are willing to learn, to work together internally in our respective organizations. This is a phase of management that top executives must recognize and to which a great deal of time and consideration must be devoted. We cannot escape the fact that the human and social needs of any organization represent problems that must not only be handled delicately but efficiently.

In the past it was too often considered sufficient if a supervisor made decisions and issued orders with no consideration to the adverse effect that these would have on those under his supervision. This method of acting first and thinking later has become outmoded. The successful supervisor must be able not only to order but to lead; to inspire those under him to do their best; and to encourage them to use their mental faculties in the performance of their jobs.

A pretty good yardstick of a supervisor's worth is his ability to properly educate and train his subordinates to do their work efficiently, and in instilling into them the desire to do the best job of which they are capable.

The human relation job of creating in each man a sincere desire to perform his job to the best of his mental and physical abilities is not an easy one. It represents possibly the greatest undertaking facing industrial management today. This is particularly true in the case of large organizations where the individual employee plays only a minor, yet extremely important, part in the manufacturing or development of a finished product.

Improved human relations in industry surmounting of many problems and they can be met by tying the employee in more closely with the company's plans and program and by giving the employee greater stature and more recognition. The accomplishment of this can only be brought about by a long range, permanently organized, training program covering every member of management from the top down. The importance of the foremen in such a program cannot be overemphasized. This means of course that foremen must first of all be chosen with a great deal of care. The fundamental qualifications essential at supervisory level, the minimum to be considered are:

Health: In order to have sufficient energy to plan, to organize, and to work.
Character: High moral qualities, firmness, reliability, and integrity.
Intelligence: Common sense, judgment, common basic capacity to reason.
Personality: Leadership, tact, ability to get along with others, friendliness, ability to get things done.
Education: High-school training or an equivalent in study.
Potentiality: Capacity for advancement.

The foremen must be constantly trained in company policies and techniques designed to keep morale and teamwork at a high level. His superiors, all the way up to the top, must also undergo training which is designed to bring about the very best morale and human relationships. All of this is aimed in the direction of company loyalty. Certainly it would be unreasonable to expect a foreman to be able to sell the idea to those who work with him that "his company is the best in the industry" unless he believes it himself. And it is just as unreasonable for top management to expect complete foreman-level loyalty unless it is proved to the foreman that his place in the scheme of things is important.

Management must take personal interest in every employee as a human being and if special interest is closely and consistently demonstrated in daily contacts, in application and explanation of policy, individual coaching, action on grievances, etc., this phase of management's responsibilities will not only become effective but it will prove to be interesting because of its close alliance with the employee's personal goals or growth and achievement.

The employee in turn will feel that he is really a part of the team and that he himself plays an important personal role in the scheme of things. The development of pride of workmanship in the employee by according him proper recognition of his performance and skill should be the goal of every supervisor.

The foreman must understand and recognize the basic attitudes and sentiments which the employees themselves bring to their places of work. He must encourage opportunities for self-expression and freedom

G. W. E. NICHOLSON, Executive Vice-President, Union Bag & Paper Corp., New York, N. Y.

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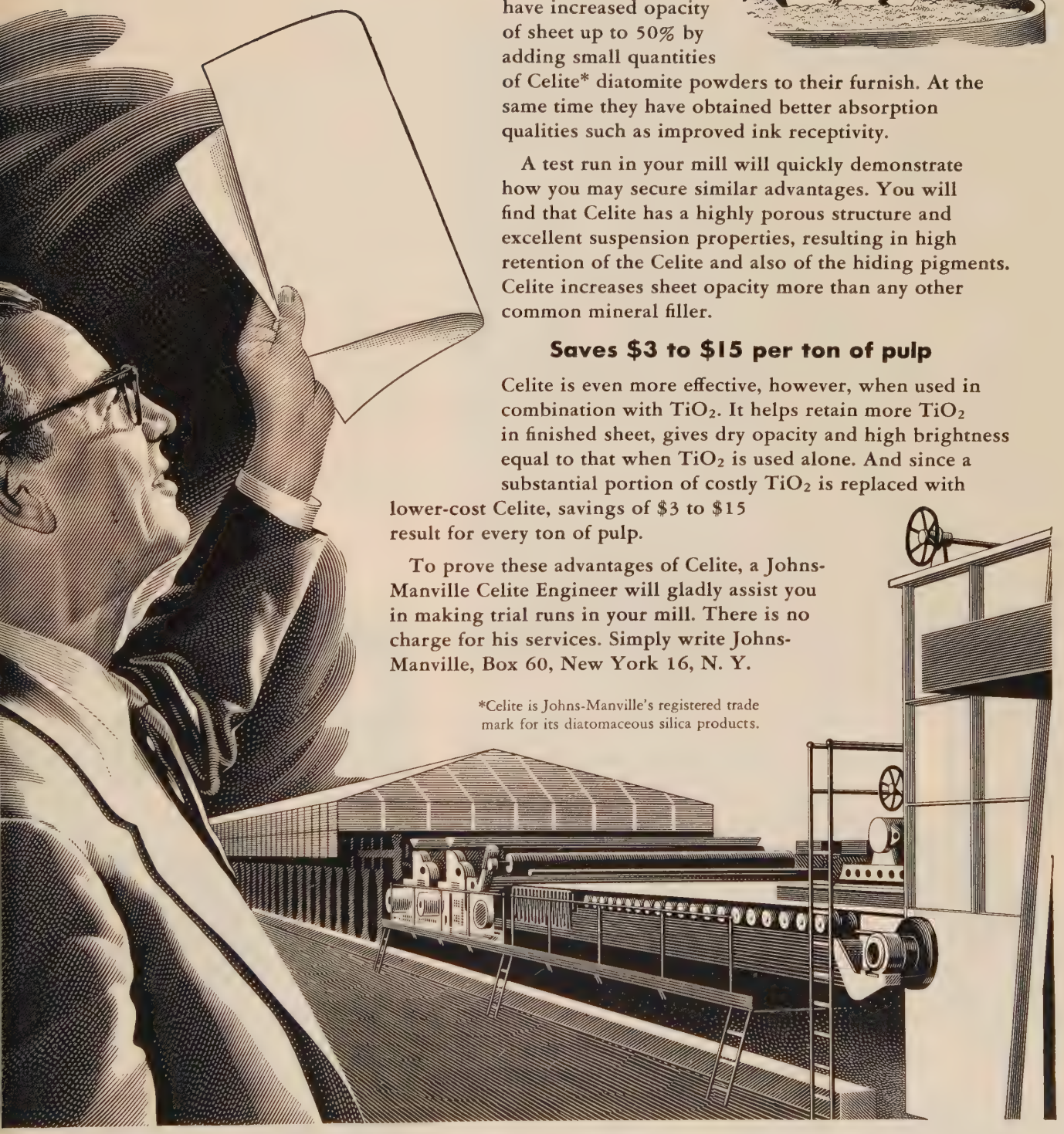


JOHNS-MANVILLE JM PRODUCTS **Johns-Manville CELITE** PRODUCTS FOR THE PAPER INDUSTRY

on the job by the individual workman. It is generally recognized that the good foreman has a personal feeling for his men and that he trusts his men. He approaches his work specifically rather than generally and talks about cases rather than principle in describing his problems and his approach to them. He has the courage to stand up for his belief.

Such foremen should be encouraged as they build good work relationships which leads to quality performance and company loyalty. The men in the ranks must be given an opportunity for self-development and recognition. The men should be led, not driven, and we should help them to do a good job and when they do a good job they should be told so. When they are doing a job poorly, proper and full explanation should be given as to how it should have been done.

Management can bring about an improvement of foreman-worker relationship by providing an atmosphere which recognizes the importance of human needs as well as the necessity for quality and output in the manufacturing process.

There are many avenues that are open to us in giving recognition to the employee as an individual, such as giving him information on new developments, and keeping him advised as to changes in his job or in the plant or the company. Those changes which will affect him as an individual are of prime importance to him. He should be encouraged to make suggestions which should be carefully considered, and he should be encouraged also to avail himself of those courses of study which the company or available schools might provide.

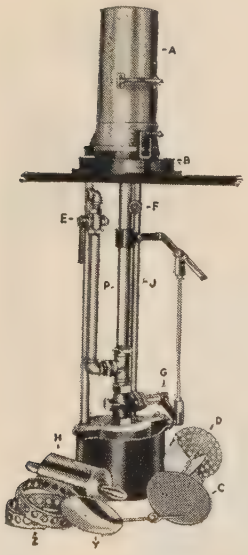
What is most important, he should be given an opportunity for promotion and self-development.

In general, a continuous, intelligently planned program of man-to-man training should, in the years ahead, develop in the employee a greater respect for his job and bring about an increased interest and happiness in his work. Any such program of development dealing directly with the human equation in business should be supplemented with vocational and educational training programs. The vocational training should be basically for the purpose of giving the employee the opportunity to learn more about the technical aspects of his work. Employees also should be encouraged to further their education through the use of correspondence courses.

The awarding of college scholarships to qualified employees and sons of employees, while having no direct bearing on current human relations problems in industry, is bound to pay off in the future. It is by this means that many companies hope to develop men from within their own company families for many of the positions required in the management rank.

All of us are proud of the fine equipment in our plants. We like to break production records and we strive constantly for improved quality and efficiency. This is as it should be. But we should be ever mindful of the fact that the people who work with us are our greatest asset, and that the most important function of management is the development of these people and not the direction of things.

Presented at the Southeastern Section of the Technical Association of the Pulp and Paper Industry, Savannah, Ga., May 14, 1954.



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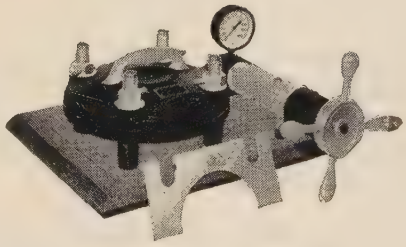

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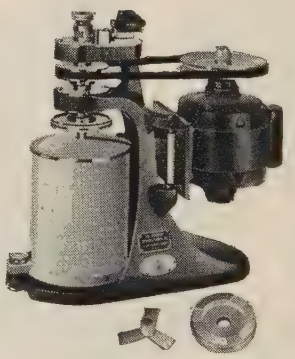
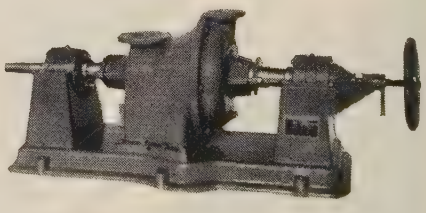


★ DISINTEGRATOR



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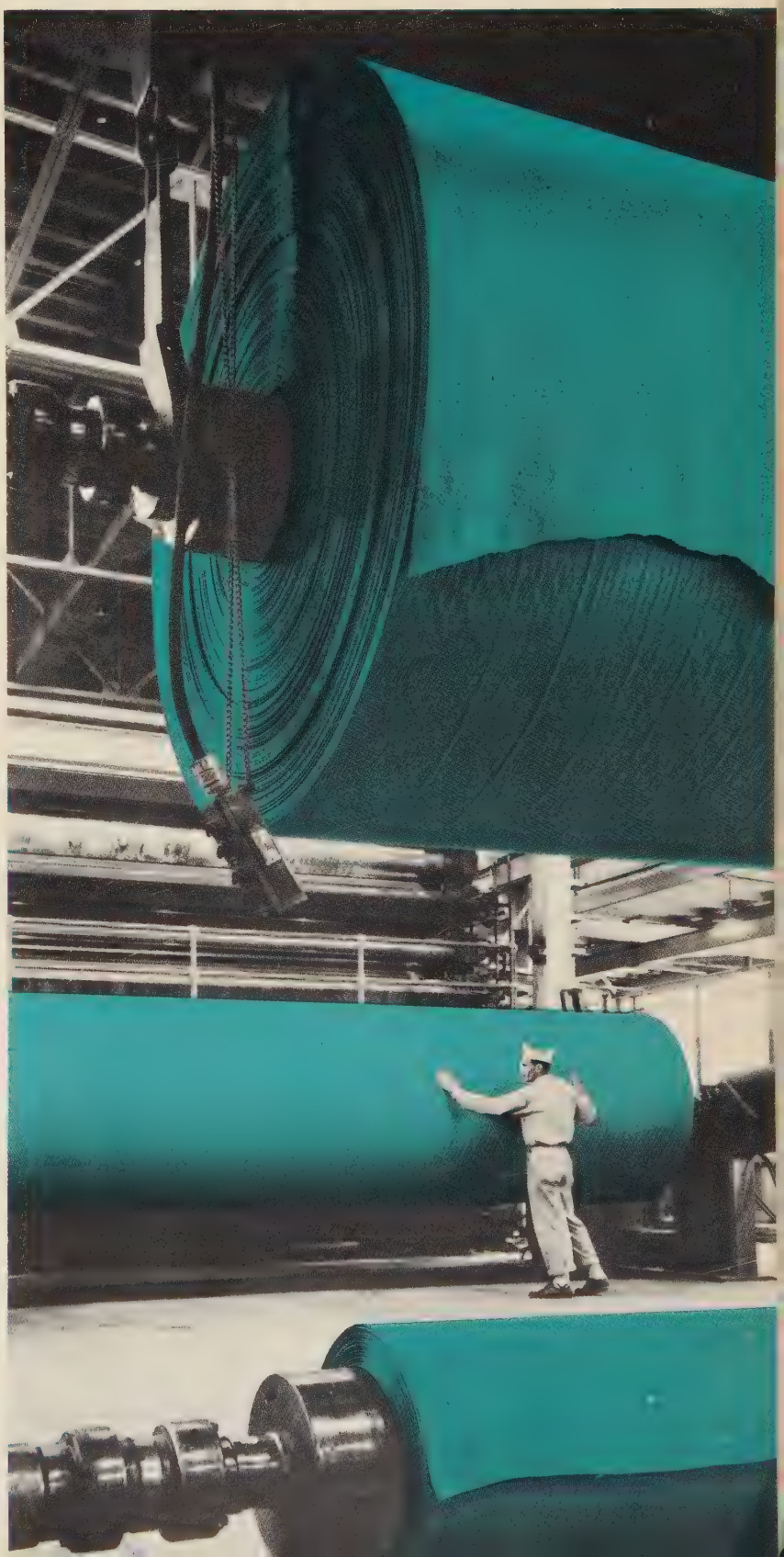

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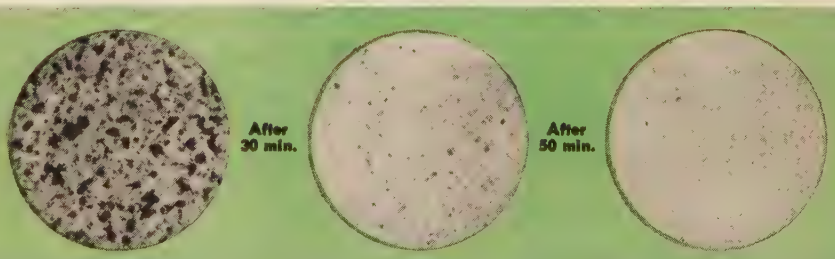
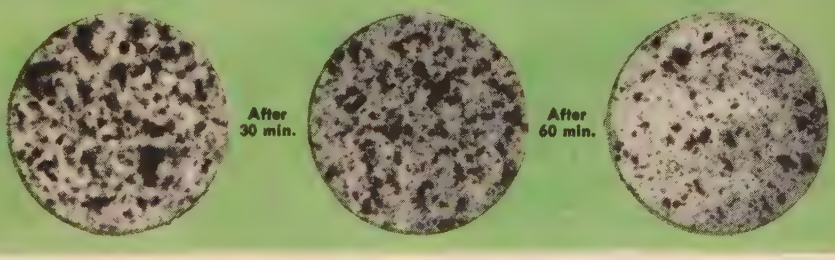
Actual unretouched "shadowgraph" photos of papers made of stock taken from run of hard-pressed unbleached pulp in PULP-MASTER with Mark II Rotor, at intervals shown.



Actual unretouched "shadowgraph" photos of papers made under same conditions from same stock while being defiberized by conventional pulping method, at intervals shown.



Developments in the Graphic Arts—1953

R. H. SIMMONS

DEVELOPMENTS in the graphic arts is an annual item written by the author from information obtained by reviewing the various technical and trade magazines. Where possible, references are made to the original article or source of manufacture. No bibliography has been included this year since it is felt sufficient information is included with each reference to locate the source of the article.

PAPER

Barrett K. Green (U. S. pat. 2,641,557 (June 9, 1953)) has a paper coated with attapulgite (attapulgus) clay in a mixture of 1 part attapulgite to 3 parts of water containing 1 part starch solution made by cooking 20% paper-coating starch with water at 200°F. for 15 min. The paper thus treated is receptive to ink but resists bleeding. The good printing characteristics of the paper are attributed to the needle shaped crystalline form of the clay which makes it highly ink receptive but, due to the cob-pile formation, prevents bleeding of the ink.

R. W. Hagemeyer (*Paper Ind.* 35, No. 7: 783–784 (Oct., 1953)) has a report on new developments in paper coating pigments. He states that chemically precipitated calcium carbonate can be controlled as to particle size; that the finer the particle size, the higher the gloss obtained. Precipitation eliminates the undesirable inclusions found in the natural products, giving improved ink receptivity, brightness, opacity, and the neutral white creates better color contrast in color printing.

L. H. Silvernail and E. J. Heiser in (*Tappi* 36, No. 10: 172–176A (Oct., 1953)) report on size press coatings using Dow Latex 512-K (a copolymer of styrene and butadiene) to produce coated papers without additional coating operations. Offset printing press performance was found satisfactory.

Edward Jahoda (Can. pat. 495,662 (Sept. 1, 1953)) has shown that a conventionally sized paper, coated with submicroscopic silica particles, gives a superior printing surface.

The Gummed Products Co., Troy, Ohio, is offering a gummed offset enamel which has excellent finish and smoothness on the printing side and is suited to all types of labels, including work requiring multicolor high gloss ink.

Richard J. Grimm (U. S. pat. 2,617,743 (Nov. 11, 1952)) has a method for making coated paper moisture resistant which consists of spraying the coated sheet using casein or soya protein adhesive, treating with a mixture of steam and formaldehyde at the calenders, and then calendering.

The Beveridge Paper Co., Indianapolis, Ind., is offering a new grade of water-repellent, weather-resistant board for outdoor displays.

Owens-Corning Fiberglas Corp. (U. S. pat. 2,620,851 (Dec. 9, 1952)) has developed an inorganic sheet material which is useful in electrical insulation tape. It is composed of felted asbestos and glass fibers with a reinforced interwoven glass fabric between the webs. The product is less than 0.01 in. thick and runs about 45,000 yd. to the pound.

E. I. du Pont de Nemours' Teflon (*Modern Lithographer* 21, No. 10: 167 (Oct., 1953)) is a resin-coated glass fiber fabric. The material has an extremely low coefficient of friction, will not pick up ink, and is not affected by the acids or solvents used in printing. It is finding use in reducing friction on presses, folders, collators, and other places. This lack of friction and tendency to adhere to anything helps prevent smudging of ink when the folder rolls or collator troughs are covered with Teflon.

The fiber obtained from the kenaf plant (*Hibiscus cannabinus*), also known as bimlipatam jute, ambari, or deccan hemp and mesta has properties which make it suitable as a substitute for jute and a possible raw material for paper manufacture. The plant grows well in almost any locale of moderate climate and does not require the ideal conditions and soils which are necessary for jute.

A laminated product, called Microwood (*Graphic Arts Monthly* 25, No. 4: 190 (April, 1953)) consists of a finely shaven layer of wood laminated to a thin sheet of paper, total thickness 0.005 in. It is said to be the thinnest product of this type yet produced. The material can be stamped, printed, painted, lacquered, varnished, waxed, oiled, punched, ground, or polished.

John D. Kendall and Douglass J. Fry (U. S. pat. 2,649,385 (Aug. 18, 1953)) have a method for optically bleaching fibrous material. Although their patent is for textiles, it might apply to other fibrous materials. It is classed as an optical brightening agent containing 3,3′-dimethyl-5-methoxy-5′-methyloxacyanine *p*-toluene sulphonate or similar compound.

The American Cyanamid Co., in its Paper Chemicals Dept., Technical Bulletin 29-B (1953) reports on Cyron size. It is a synthetic size originally prepared to size papers on the alkaline side. The size can be used as a beater additive or a surface size. It adds to the ink resistance of the paper as shown by the resistance to butyl carbitol. This size assists in preventing curl in the paper and as such should be of advantage in preparing printing papers.

PAPER TESTING

George K. Boger, Jr. (*Paper Trade J.* 136, No. 14: 21–22 (April 3, 1953)) reports on the du Pont fiber identification stain A. The stain is a mixture of dyes which has prospects for use in the qualitative identification of sizing agents, spot and speck analysis, and for the determination of the degree of beating of pulps.

R. H. SIMMONS, Chemist, U. S. Government Printing Office, Washington, D. C.

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A. N. J. Heyn in *Textile Research J.* 22, No. 8: 513–522, Aug., 1952, reports on the use of birefringence and refractive index of synthetic fibers. These properties have proved to be much more consistent and characteristic for synthetic fibers than for natural fibers and rayons. By the use of a simple polarizing device and an ordinary microscope they can be used for the identification of the synthetic fibers.

F. T. Carson and Vernon Worthington (National Bureau of Standards Research Paper 2376) have developed an instrument for measuring the stiffness of paper. The specimen is bent through a given angle and its stiffness is measured by the torque in a wire suspension. By varying the width and length of the specimen and the angle through which it is bent and by varying the size of the supporting wires an instrument of this type can be used to measure papers having a wide range of stiffness.

A. Olsson, I. Arnamo, and L. Pihl (*Svensk Paperstidn.* 55, No. 18: 709–714 (Sept. 30, 1952)) pull a strip of cellophane tape from the surface of the paper at a fixed tension and speed by means of a Schopper tensile strength tester. This method measures the maximum force needed to split the surface of the paper. The results compare favorably with the Dennison wax test. The pick strength is largest in the machine direction. The method does not indicate dusting.

The Andrew Technical Service, 3805 N. Clark St., Chicago, Ill., has a paper humidity guide which consists of a paper strip with a series of seven color circles, which colors indicate the relative humidity in a range from 10 to 70% in 10% increments.

G. J. Leighton in *Electronics* 25, No. 12: 112–113, Dec., 1952, states that Isotope Products, Ltd., Oakville, Ont., have a radioactive thickness gage which takes measurements at the wet end of the paper machine. This method provides a higher sensitivity and closer control of the web thickness.

Walter Brecht and Adam Wesp in *Das Papier* 6, No. 17/18: 359–367, Sept., 1952, and 19/20: 411–415, Oct., 1952, have an instrument which measures the intensity of the cloudiness of a web of paper as well as the distribution of the cloudiness.

A. E. Williams (*World's Paper Trade Rev.* 138, No. 6: 421–423 (Aug. 7, 1952)) reports on electron diffraction for the examination of the surface and internal structure of paper.

The Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda, Md., has a dust compensated 75° gloss recorder using a photoelectric sensing unit and electronic measuring device which may be mounted over a moving web to record the gloss of the paper as it is processed.

PRINTING INK

There are reports on two new drying agents for printing inks. Vernice, Inc. (*Milan* 3: 13–14 (1949)(*C.A.* 46: 11706)) states that the drier salts of 2-ethylhexanoic acid have certain advantages over the naphthenates in that they have a uniform composition and are not sensitive to oxidation. Also, they are colorless.

R. T. Vanderbilt, Inc., New York, N. Y., recommends ortho-phenanthrolene. It exerts a polymerizing effect and when used in inks, decreases the amount of metallic drier required. It also does not lose its drying power.

The Ames Laboratories, Inc., 132 Water St., South Norwalk, Conn., has an antiskinning agent called Ink-Sav which can be added to a partly used can of ink or in the ink fountain to prevent skin. The material is colorless and volatile. It evaporates when the ink is used and does not interfere with the color or drying rate of the ink.

The Gould Laboratories (*Graphic Arts Monthly* 25, No. 1: 222 (Jan., 1953)) has an ink stabilizer which can be added by placing a few drops on the ink rollers and running for a few seconds. The ink will not skin overnight. This method can be used in makeready and saves wash-up between makeready and running the job. This compound is claimed to make the printing plate more receptive to ink and lengthens the life of the plate. The compound mixes with varnish, is water insoluble and will not emulsify with fountain solution and acts as a rubber preservative.

The Etter Co., Lake Mills, Wis., is dispensing an ink gun which uses special fiber cartridges, containing the ink, with a plastic nozzle which permits viewing the color of ink. The gun is the pressure type with a squeeze trigger which permits case of filling the fountain without waste and with no skin in the container.

The Sav-Ink Co. (*Graphic Arts Monthly* 25, No. 11: 220 (Nov., 1953)) has a similar system for dispensing ink.

Bensing Brothers & Deeny, Philadelphia, Pa., has developed Excellobrite flexographic ink. It is a high-gloss ink for printing on the various types of cellophane and will not block even at 130°F. or 90% relative humidity. The ink is fast drying, 100% pigmented ink that does not bleed in film plasticizers.

Pope & Gray, Inc., Clifton, N. J., reports in the *American Ink Maker*, June, 1953, that they have a new gold ink, called Metlak offset gold, made by mixing a finely powdered bronze specially prepared with a new varnish.

The floating roll mill as reported by Ernest Gamble, W. C. Walker, and A. C. Zettlemoyer in the *American Ink Maker* of June, 1953, is a development in ink grinding. The middle roller of a three-roller mill instead of being a fixed roll as heretofore, is allowed to float and adjusts its relation to the front roller, which is now fixed, by adjusting the back roll. It is claimed that the output as well as the quality of the grind is increased.

E. Kroenberg in *Farbe u.- Lack* 58: 263–264, 1952, tells of the use of ultrasonic treatment in the preparation of paint. A laboratory ultrasonorator with a sound input of 150 w. per sq. cm. and frequency of 8000 kHz for 10 min. was used on varnish. The varnishes were heated up to 90°C. but showed no unfavorable changes other than an increase in viscosity. Varnishes were then mixed with pigments in the usual grind ratio and subjected to the ultrasonorator at a sound input of 20 w. per sq. cm. and a frequency of 800 kHz for from 4 to 8 min. The result was a perfect paint with a glossy film free from coarse particles.

The Anolith process, American Anode Div. of B. F. Goodrich Co., permits a 300-line screen to be transferred to rubber or plastic. The impression is first made on paper and then transferred to the rubber. A slight curing permanently seals the image to the rubber.

Y. I. Zolontski, B. N. Shakhal'dyan, and E. S.

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Zolonitskii in *Poligraf. Proizvodstvo* 11: 25–26, 1951, have an instrument to measure the adhesiveness of printing inks. It consists of a small roller mounted on a slide attached to a spring balance. The roll is allowed to contact a wheel coated with the test ink and rotating at a standard speed. The pull on the roller at a given velocity is translated into terms of adhesiveness of ink.

A portable automatic inking device (*Printing Equipment Eng.* 83, No. 3: 89 (Dec., 1952)) has been developed for the no. 4 Vandercook proof press. The ink distribution is so accurately controlled that all samples of paper tested are subject to identical conditions.

The British Printing Ink Association, Technical Committee (*Paper Box and Bag Maker* 60 (Jan., 1953)) has determined that the weighed copper-shell technique developed by PATRA should be used in the preparation of standard prints to be used in tests relating to light fastness and color measurement of printed matter.

PLASTICS

The Plastype Co., 788 Railroad Ave., Bridgeport, Conn., is producing a plastic type to replace wood type. The entire font is cast at one time by pouring a thermosetting resin plastic into the narrow space between the mold and a piece of hardwood or plywood backing. The assembly is then baked for 24 hr. at 140°F. The plastic fuses firmly with the wood back and gives an extremely tough face which can be used under mat rollers which would normally hurt wood type. The cost is well below that of wood type.

Vasel Manufacturing Co., Philadelphia, Pa., is offering Perfex, an improved top sheet for letterpress. The sheet consists of a smooth, hard, synthetic surface with a resilient backing. The backing compensates for slight unevenness of printing surface, reducing make-ready time, and the hard surface is long wearing and resists the effect of roller wash, making it easily cleaned with ordinary roller wash. The sheet is moistureproof and does not swell in high relative humidity. The resilient backing makes hard packing unnecessary for solid forms and there is a decrease in the formation of a matrix and the top sheet need not be changed for each job.

The Chicago Molded Plastics Corp., Chicago, Ill., is producing a plastic alloy polystyrene and rubber formed through a heated die. The sheets can be made any length in widths from 26 to 58 in. and thicknesses from 0.005 to 0.125 in. Any color and finish from high gloss to matte can be furnished. The comparatively low cost of the material permits its use in display, advertising, and the graphic arts. Possible uses are for stereotype mats and printing plates. Special inks are needed in order to print on the material.

Harry E. Conners and Arch L. Hatfield were awarded U. S. pat. 2,636,870, April 28, 1953, for an aqueous synthetic resin dispersion which produces nontacky and nonblocking films and coatings. The resin dispersion consists of a mixture of 75 to 90% by weight of vinylidene chloride, 5 to 15% of vinyl chloride, and 5 to 15% of an alkyl acrylate in an aqueous emulsion. A paper or boxboard coated with this material is flexible and resistant to water vapor and grease and may be heat sealed.

Metal Film Co., 29 Broadway, New York, N. Y., is producing a metallized acetate film with pressure-sensitive backing. The film comes in widths of 20 in. with a satin finish. The colors are gold and silver which are locked into the sheet and will not fade, scratch, or chip. The film is easy to print on.

Firestone Plastics Co., Pottstown, Pa., has Exon 400, XR a nonflammable fluorinated resin which is inert to inorganic chemicals, heat, and light. The resin is soluble in selected organic solvents and is recommended for application to metal, wood, plastics, textiles, asbestos, and paper. Due to its resistance it gives protection to metal containers against concentrated sulphuric and nitric acids.

Modern Plastics 31, No. 3: 182, Nov., 1953, lists the application of a vinyl latex spray (Geon) for the restoration and preservation of old paintings and documents to protect them from dirt, insects, gases, bacteria, oxidation, and atmospheric conditions.

The *Graphic Arts Monthly* 25, No. 2: 210, Feb., 1953, reports on a revolutionary method of producing Braille printing. A master stencil is cut in the old embossed manner. Stencils for printing are then produced from this master by a phase modulation and probe antennae scanner to actuate the punch. The stencils are mounted on two hollow drums inside which operate two periprinters. The article gives a fairly complete description of the periprinters. The ink used is a urea-formaldehyde, water-based syrup with plasticizer, filler, lubricator, and swelling agent which can be used at high speed (4000 to 5000 r.p.h.). The ink has good adhesion for the paper, good strength, and a smooth surface when dry. Drying is accomplished on the machine by the use of two electrodes which cause molecular agitation and heating of the ink by rapid change in the field. An accelerator is used in the ink which evolves a small quantity of acid which starts a chain reaction which with the heat, hardens the dot in a few seconds.

Electrochemical Laboratories (*Graphic Arts Monthly* 25, No. 6: 202 (June, 1953)) has a carbon drawing ink suitable for use with plastic film. The ink has the covering power of India drawing ink and is so stable it can be used in some fountain pens. The ink has good adhesion on glass, smooth cellulose acetate, cellulose nitrate, methacrylate, and numerous water-repellent, smooth plastic surfaces. It has good wear resistance and heat stability and does not flake due to repeated rolling of the film. The drying time is 2 min. and a brief heat curing at 180°F. makes the ink water resistant.

Samuel Sacks of the Coast and Geodetic Survey (*Modern Lithography* 21, No. 2: 38 (Feb., 1953)) tells of the use of a plastic coating on a film base. By the use of the proper coating, scribing and engraving techniques for preparing maps and charts can be applied. The results are clean and clear lines.

The Chester Packaging Products Corp. (*Printing Equipment Eng.* 83, No. 11: 6 (Aug., 1953)) has a surface treating process which increases the printability of polyethylene film. "Cheslene TF" can be printed by a wide number of printing processes with maximum coverage and high uniformity of impression.

PHOTOGRAPHY AND COLOR

J. D. Kendall of Ilford Ltd., London, England, re-

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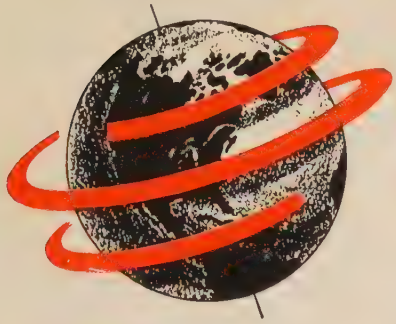

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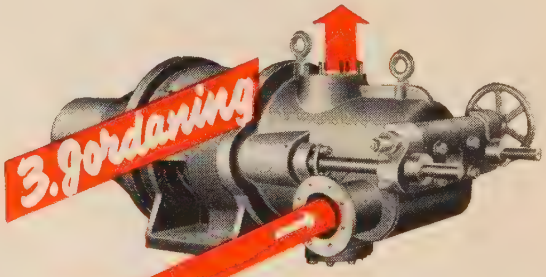

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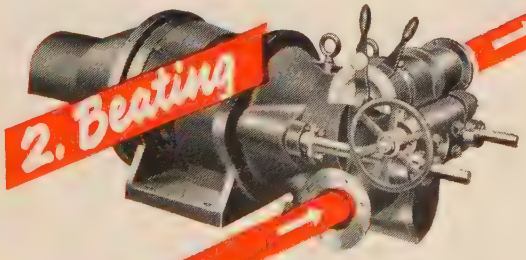

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ports that phenidone far surpassed metol in photographic developers. Phenidone is far less toxic than metol. It is more active and more economical to use and keeps better in concentrated solutions. A PQ (phenidone-hydroquinone) developer is capable of activating other developers such as paraphenylenediamine and gives excellent fine grain development. The rate of exhaustion is lower than metol developers of a similar nature. The oxidation products are colorless in nature and so less likely to stain the hands, and the developer does not cause skin rash.

Morton Schwart (U. S. pat. 2,599,518 (June 10, 1952)) has a high-contrast hydroquinone developer of improved working life which is obtained by replacing the CH_2O releasing compound used in prior formulations with a (hydroxymethyl) hydantoin, e.g., 5,5-dimethyl (hydroxymethyl) hydantoin.

Modern Lithographer and Offset Printer 49, No. 4: 18–19, April, 1953, reports that several photographic papers now contain fluorescent dyes to make the paper appear brighter. When the prints are used for photomechanical reproduction on color-blind film, more exposure time is required due to the fact that the fluorescent dye converts some of the blue light to longer wavelengths to which the color-blind emulsion is not sensitive.

Modi-Graphic Inc., (*Graphic Arts Monthly* 25, No. 3: 206 (March, 1953)) has a photodimensional and proportioning camera called the "Photomaster"which by using a unique system of prisms and lenses can control both the vertical and horizontal dimensions and yet retain all of the original characteristics of good layout and composition. By proper operation the camera can stretch or condense, increase or reduce the weight, create italics from roman in a one-shot operation. Outline letters can be made from solid type and a straight line of type can be changed into any kind of perspective or curve.

Filmotype Corp., 60 W. Superior St., Chicago, Ill., is producing a portable typesetter weighing only 40 lb. It incorporates all popular type styles in sizes from 10 to 144 points. As many as 20 typefaces may be used in a single composition. Screen tints for special effects can also be had.

John S. Odell in *Photoengravers Bull.* 42, No. 4: 149–154, Nov., 1952, reports that the Interchemical all-electronic color correction device is being developed by RCA and that commercial models are expected soon.

The Screen-A-Color analyzer developed by Wm. J. Fintze and produced by The Lezius-Hiles Co., 1125 Rockwell St., Cleveland, Ohio, enables people responsible for planning color jobs to see what results will be obtained before the work is actually on the press. The device uses standard printing screens of known value and colored inks. These can be shown together with overprinting or reverse printing and in various combinations of screen values and proportions.

Vincent Subenski of Superior Printing Ink Co., New York, reports on a method for obtaining color proofs without a press. The grained side of a plastic sheet is coated with a colored coating prepared by producing a colloidal suspension of lithographic pigments in a light-sensitive vehicle. The plate is exposed through a negative and developed with dilute ammonia. The resulting prints are permanent.

The Sta-Hi Corp., Whittier, Calif. has a precision color comparator and registering machine. Mats, plates, and proofs of color copy can be matched for perfect register through an ingenious and finely sensitive optical projection system. The accuracy of register marks can be checked and if the impression can be brought into register and the original marks are off, new marks can be made.

OFFSET PROCESS

Frost and Brinnick (U. S. pat. 2,624,673 (Jan. 6, 1953)) have a formula for manufacturing a presensitized printing plate. It is composed of a planographic printing surface coated with a dried aqueous compound of a nonprotein hydrophilic organic film-forming hydrocolloid of the group consisting of methyl cellulose, hydroxyethyl cellulose, sodium carboxymethyl cellulose, polyvinyl alcohol, polyvinyl pyrrolidone, sodium acrylate, gum arabic, gum ghatti, and mesquite gum which is capable of being tanned by actinic radiation in the presence of ammonium dichromate, a hexavalent chromium compound.

Azoplate Corp. (member of Englehard Industries) Summit, N. J., has the Enco presensitized litho-offset plate which after exposure can be densensitized, developed, etched, and gummed by one solution, Enco Finisher F-1. The solution is not flammable. The plates have a long shelf life and are capable of long runs or reruns.

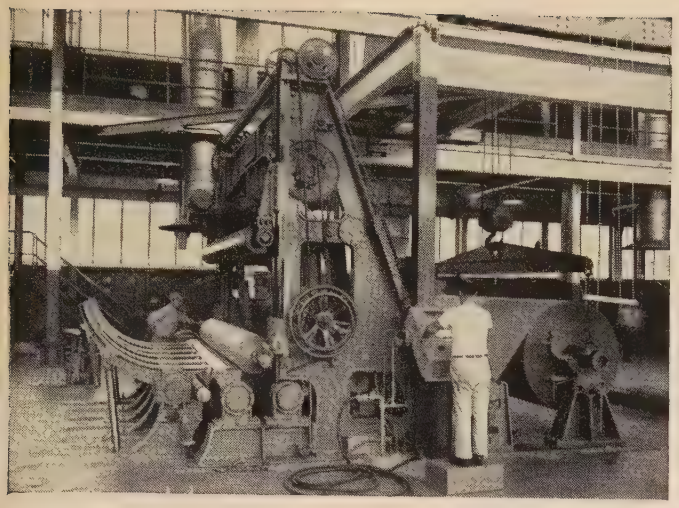
Remington Rand, Inc., also has a presensitized plate called Photospeed Plastiplate. This plate can be exposed and wiped with a desensitizing solution and is then ready for the press. Exposures are said to be 60% faster than an ordinary litho plate. Errors in the negative can be corrected on the plate and when dry, the plate can be typed or written upon with a ball point pen.

The Polychrome Corp., Yonkers, N. Y., has a plate (Polychrome Economy Presensitized Plate) with nonmetal base suitable for line and halftone work. Deletions can be made with a rubber eraser and the erased spots will not tone. The plate is not subject to scratches and may be handled in ordinary room light without affecting the plate.

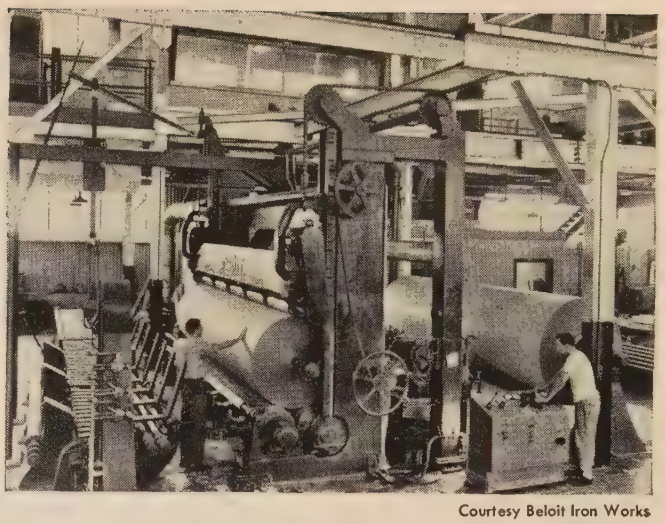
The Harold M. Pitman Co. has a metal litho plate for one-time use. The plate has a fine, uniform grain satisfactory for use in reproducing the finest dots and lines but still deep enough for good water control.

Walter J. Hausman (U. S. pat. 2,637,929 (May 12, 1953)) has a method for improving the life and moisture resistance of aluminum plates. A plate of 99% pure aluminum is scrubbed with a rotating steel-bristle brush (bristles 0.09 to 0.05 in. in diameter) traveling at a peripheral speed of 1400 f.p.m. The plate is then treated with a bath of saturated calcium hydroxide solution at 180°F. for 35 to 40 sec., then scrubbed with a fiber bristle brush under a water spray and dried.

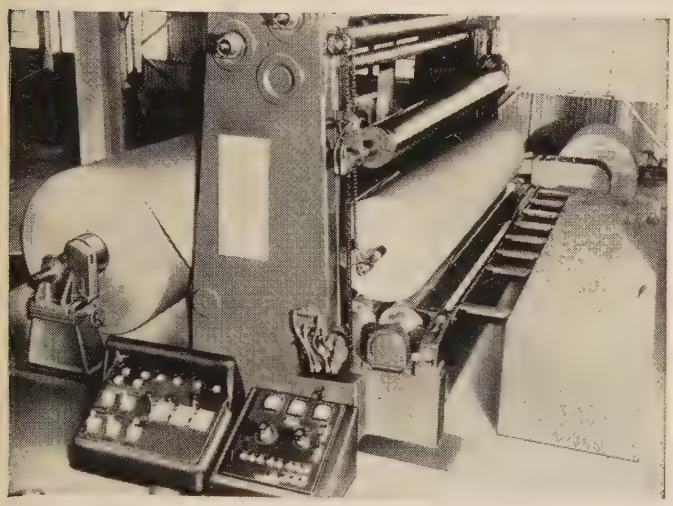
Douglas A. Newman (Can. pat. 492,980 (May 19, 1953))(assigned to Columbia Ribbon & Carbon Manufacturing Co.), has a paper plate coated with carboxymethyl cellulose or a salt or derivative of carboxymethyl ether which has proved satisfactory for lithography. The coating incorporates fillers (such as china clay) which hold the image and plasticizers (such as glycerin) which make the plate pliant.



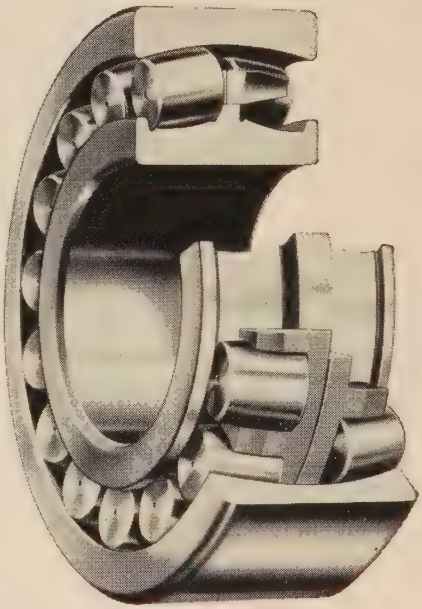
Courtesy Pusey & Jones Corp.



Courtesy Beloit Iron Works



Courtesy Bagley & Sewall Co.



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The S. D. Syndicate Ltd., has Brit. pat. 675,972 which is classed as an improvement in lithographic plates. The plate is composed of stainless steel, the surface of which has etched cavities lined with copper or brass.

The combined work of the Lithographic Technical Foundation and Printing Developments Inc. (subsidiary of Time Inc.), has produced a low-cost grainless copper-aluminum offset plate for the negative film process. With no grain, greater clarity and sharpness of the image are obtained. The plates are made in sizes up to 77 in. On the press the plate is claimed to give sharp prints immediately. The plate uses less water giving stronger color with less emulsification and thus eliminates scumming and tinting.

H. E. Swayze (Dow Chemical Co.) reports on a new method for etching which cuts to printing depth on magnesium in $^1/_5$ to $^1/_{10}$ the time of methods already in use. Plates etched this way can be used for direct printing or for the preparation of duplicate plates. This method is expected to prove of importance in the preparation of dry offset plates.

Eastman Kodak Co. has a water-insoluble plastic coating which has exceptionally high stability coupled with a high photosensitivity. It is said to be unaffected by changes in humidity or temperature and keeps its high speed indefinitely. Plates can be coated weeks in advance. When exposing the plates a white flame arc is used. The coating contains no chromium salts but gives plates with consistent uniformity, short exposure time, freedom from scumming, and with better acid resistance. It is satisfactory for coating all metals and it is not necessary to burn in the image. Plates made from this coating have been run up to 900,000 impressions in trade tests.

Charles W. Harrold (U. S. pat. 2,619,901 (Dec. 2, 1952)) has invented a mechanical means for varying the length of the impression on a rotary press. The change is caused by producing a predetermined gradually increasing forward angular movement of the blanket cylinder with a similar movement of a cooperating cylinder. Both cylinders return to their normal position before the blanket cylinder contacts the plate cylinder on the next revolution.

A. C. Mathews (*Penrose Annual* 47: 129–130 (1953)) reports that the Coates' Spiralchrome scavenger roller is especially suitable for controlling the dampening of bimetallic plates. Narrow helices of chromium are placed on the roller, leaving alternate helical areas of basic brass or copper-plated steel. The chromium areas feed the water forward when passivated as for bimetallic plates and the brass or copper areas collect the ink.

The A. B. Dick Co., Chicago, Ill., has reported on an effuser dampening system for lithography. Water is applied to the plate by a metal roller spaced 0.004 in. from the plate surface, after which an air blade removes the excess water. The air blade slot is 0.010 in. wide and is set 0.015 in. from the plate surface. The air pressure is quite low and the water discarded is pulled into a vacuum chamber.

The American Stencil Manufacturing Co., Denver, Colo., has a fluid Sure-Rite Smudge-A-Way for use with the Sure-Rite direct image plates. The fluid removes or neutralizes all fingerprints, ink smudges, and smears. The use of the solution helps to sharpen the reproduction by washing away hairlines and weak "fuzz" around the outside of the letters without affecting the life of the plate.

Graphic Products Co. (*Graphic Arts Monthly* 25, No. 1: 229 (Jan., 1953)), has a material, Blanket Fix, which is said to quickly and permanently correct low spots on the litho blankets without having to remove the blanket from the cylinder. The action is entirely chemical and no uneven pressure areas are caused, nor is the printing image distorted.

Harry H. Rogers Co., Inc., Chicago, Ill., has a new solution which is said to extend the life of albumin plates. The solution builds up the nonimage area to the same level as the image. The tough, hard layer protects the image tripling the productive life of the plate. The plate is made as usual and then before gumming, the solution is applied to the whole plate and then exposed to an arc light for $^3/_4$ of the original time, then rinsed. When dry the plate is gummed.

Haerinek and Urbain (*Graphica* 33, No. 6: 45 (July-Aug., 1952)) have a Belgium patent for a new graining marble. The marble is a light aluminum alloy composed of aluminum 80 to 90%, copper 2 to 4%, silicon 4 to 6%, magnesium 1 to 3%, manganese 1%, nickel 1.5 to 2.5%, and zinc 2 to 4%. The alloy is made in such a way that the sand sticks to the outside of the balls during graining.

Miami Valley Coated Paper Co., Franklin, Ohio, is producing Mask-O-Lith masking paper which has a special coating which permits the masking tape to strip clean. A special size causes the paper to resist moisture and to lie flat and not wrinkle. Titanium and special colors in the coating produce the proper translucency. The base paper is made of extra strong stock to permit handling without tearing.

The inking system on the Multilith Press (Addressograph-Multigraph Corp.), is of a size comparable to the press. It does not break down the printing ink sufficiently to eliminate ghosting and image slur on certain types of work. Several inking attachments are being produced which are claimed to eliminate these difficulties on the 1200 series of presses. S. D. Forbes, Seattle, Wash., has built a series of auxiliary rollers which aid in breaking down the ink and prevent ghosting. Litho Engineering & Research, Seattle, Wash., has an all-steel "Hefty-Roller," $2^1/_2$ lb. in weight and Pemberton Printing Co., 1200 W. 8th St., Los Angeles, Calif., has an ebonite plastic roller with a circumference of $13^1/_4$ in. These all help break down the ink, giving better printing results.

MISCELLANEOUS

James P. Ebert (U. S. pat. 2,647,464 (Aug. 4, 1953)) has an electric method of reproduction. A copy to be reproduced is placed in contact with the dielectric layer of an electrographic plate comprising a conductive backing plate with a dielectric coating layer. Subject the assembly to an electrostatic discharge, remove the original copy, and contact the plate with an electrically charged power. Then transfer the powder image so formed to a second surface. Finally fix the image on the second surface.

John B. Hartnet in *Print* 7, No. 5: 9–15, Nov., 1952, reports that the last three steps in xerography

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In the second century after Christ, when papermaking was in its infancy, macerated fibers in liquid form were poured on cloth moulds and placed in the sun to dry. The fiber was stripped from the mould after it was completely dry . . . and thus a sheet of paper was made. In America, modern high-speed machines have taken the place of ancient papermaking methods. And for more than 30 years A. E. Staley Manufacturing Company has served the progressive American paper industry, supplying high-grade raw materials to the nation's leading mills. Staley products and expert assistance can improve *your* business. Contact your supplier or write direct for details.

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have been incorporated into a machine which can produce prints at a speed of 1200 web f.p.m. The machine is sufficiently light in structure that it can be used for duplicating work. Multicolor reproduction is also possible.

The Haloid Co., Rochester, N. Y., has the Xerox-Lith-Master camera no. 4. It is a small camera which fits on a 5 by 2-ft. table. It will reduce copy up to 17 by 22 in. onto an $8^1/_2$ by 13-in. XeroX plate. Offset paper masters can be made by this method which may be reproduced by offset. Diazo reproductions can be made from translucent prints made by xerography. This camera permits reduction of copy to 50% or enlargements up to 150% of the original onto an $8^1/_2$ by 13-in.-plate.

W. Richards in *Tin Printer and Box Maker* 29: 338, March 1953, gives a brief review of ferromagnetography and its possible application to the printing of tinplate.

D. Behrman in *Unesco Courier* 6, No. 2: 8–9, 1953, describes a method of making a printing plate for poster work. A matrix is made by engraving on wax. The plate is cast by pouring a glue-glycerin composition into the matrix. This method can be used in places where there is a lack of printing facilities.

Modern Packaging 26, No. 12: 98–100, 181, Aug., 1953, describes the use of the flexographic method as adapted to letterpress or gravure in pictorial printing on corrugated stock. The method is especially designed to be used on double-faced corrugated liner stock. The best results are obtained on a well-calendered stock with "B" flute. Full-color illustrations can be reproduced.

Vandercook & Sons, Inc., has been assigned U. S. pat. 2,610,581, Sept. 16, 1952, for a multicolor proof press on which the inking of the forms and the speed of the impression cylinder are accomplished in such a manner as to provide printing conditions equivalent to those of production presses.

The American Publishers Supply, Inc., Lynnfield, Mass., has an infrared stereotype matrix drier which incorporates seven Wiegand Chromolox radiant heaters to give a uniform preheat control to the matrix by regulating the heat input in 30-sec. cycles. The heater includes a timer and a built-in blower for moisture disposal all in a well-insulated unit.

Fred Jernt is the inventor of the Jernt "Impruv-A-Mat" process (Monotypecaster Service, 5728 N. Mead Ave., Chicago, Ill.). The process constitutes treating the matrices to get a velvety surface on the casting face of the type. This face, when examined under the microscope, has a microscopically peened printing surface which is said to trap ink better and result in cleaner, blacker, more uniform prints. These matrices are said to last longer because the pores of the metal are closed in peening, making the surface harder and more wear resisting. The treatment removes up to 98% of the hairlines found in ordinary type.

Warwick Wax Co. (Division Sun Chemical Co.), has a sugar cane wax Duplicane 517, developed especially for carbon paper. This wax is said to have flow-producing properties superior to imported vegetable waxes. It disperses and dissolves all types of dyestuff used in the manufacture of carbon paper and enhances the brilliance of duplicating carbons.

The Center Tool Co., 153 Center St., New York, N. Y., has a unit which can be quickly attached to any single-web, double-web, or Orville Dutro press to give hot spot carbon impressions in any size or shape at the rate of 10,500 impressions per hour.

Keller and Dawson (U. S. pat. 2,611,313 (Sept. 23, 1952)) assigned to Hammermill Paper Co., have a duplicating carbon composed of a base sheet; of paper, regenerated cellulose, glassine, or foil, coated with a mixture of a waxy material and dye. A second coat to prevent smudging is made by treating the coated sheet with a solution of 8% coumarone-indene resin and 1% plasticizer (Herculyn) in carbon tetrachloride. This coating is dried below the melting point of the wax dye.

G. Walton (U. S. pat. 2,598,332 (May 27, 1952)) has a transfer coating composition which can be applied cold. The coating consists of a pigmented solid wax 2 to 35%, and a nondrying liquid oil 48 to 80%. The composition is normally in the form of a spreadable thixotropic gel, resistant to free flowing at 20 to 35°C. which becomes free flowing under agitation.

The Fernrae Products Co. (*Graphic Arts Monthly* 25, No. 4: 220 (May, 1953)) has a device called "Flipper" which is made of spring steel and can be attached to the feedboard of a press. The device helps to keep thin paper from buckling and heavy paper from bouncing when the paper meets the guides on the press. This device also helps control register.

Specialties, Inc., Syosset, N. Y., has an instrument called Electrostatic Locator Type D which will detect electrostatic charges and electrostatic induction. The instrument provides an indication of the amount of electrical charge on moving or stationary equipment or materials. The instrument is portable, weighing less than 4 lb. and is powered by two $4^1/_2$-v. batteries.

The Braun Laboratories, 206 S. Hutchinson St., Philadelphia, Pa., has a chemical, static eliminator; Anti-stat-1 for use on equipment and Anti-stat-2 for use on glass or plastic film.

Engineered Chemicals Associates (*Graphic Arts Monthly* 25, No. 12: 212 (Dec., 1953)) has an antistatic spray can which comes in 6 and 12-oz. cans. The solution mi-22 static neutralizer is applied from a push-button spray top can and leaves no gummy deposit or film and will not stain paper nor injure the skin.

E. I. du Pont de Nemours has an aerosol spray which kills static. It can be applied in the pressroom on the tympan, feedboard, delivery, and for longer lasting results on the packing under the draw sheet.

J. E. Dayle Co., 1220 W. 6th St., Cleveland, Ohio, has Statkill.

J. I. Biegeleisen in *Printing Magazine* 76, No. 12: 60–61, Dec., 1952, tells of the use of Ektagraphic stencil film as a presensitized stencil.

Hempel and Calbrese (U. S. pat. 2,649,381 (Aug. 18, 1953)) have a stabilized stencil ink which may be composed of 5 to 10 gal. of gloss oil, carbon black, soybean lecithin (about 5% of the carbon), and a carrier in an amount at least enough to provide a paste. The carrier is a petroleum distillate having a range of 363 to 613°F. and flash point of 166°F.

E. I. du Pont de Nemours has a new stencil film for silk screen which it is expected will have an important effect upon present silk screen printing methods.

James J. Deeney, Bensing Brothers & Deeney, reports that in Germany, rubber gravure cylinders are

Eliminate ALL these defoaming headaches

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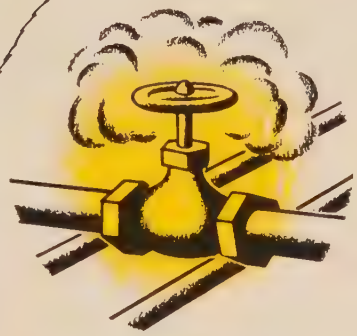
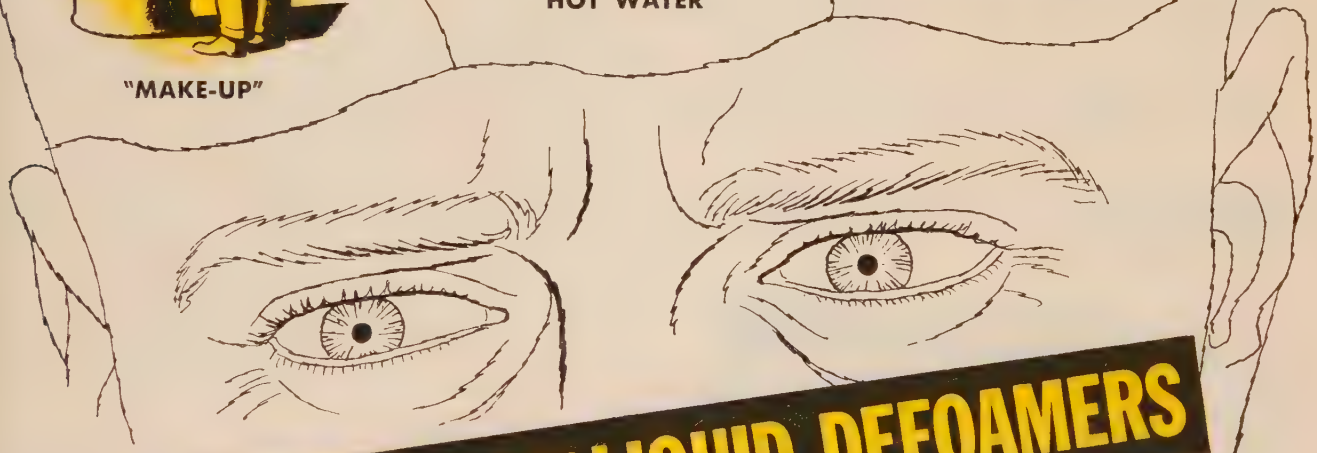
EMULSION TANKS



HOT WATER

MEASURING

"MAKE-UP"



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Of course, if you *had* to go through all the time-consuming steps shown above to get rid of foam on the wire, you'd accept them—for you can't tolerate foam and produce a quality sheet of paper. But here's good news! Nopco research has produced the LD Series of liquid defoamers, which makes defoaming not only effective, but simple and easy too.

Nopco LDC, LDF, and LDV offer all the advantages that come with effective foam control, including improved drainage on the wire, which permits higher machine speeds and—above all—a higher quality sheet. These products disperse readily to form nonionic emulsions. Nopco LDC works well on many of the most troublesome grades of paper and on difficult defoaming problems in the pulp mill. LDF has been successful on cylinder machines in board mills. LDV, a low cost formulation, has a cloud point of 28° F.—of interest to those who make paper in a cold climate.

Since Nopco makes also the famous KF Series of paste defoamers, our technical representatives can give you completely impartial advice—help you find the defoamer which works best in *your* mill, for *your* sheet of paper. Write today for testing samples and full information.

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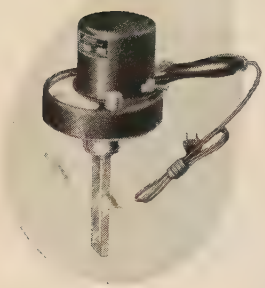
TO THE BETTER CONTROL OF COATING COLOR BEHAVIORS



With a multipoint Brookfield Viscometer on the job, it is easy to check the effect of dispersant additions on the rheological properties of your starch-clay, casein or pigment-combination colors.

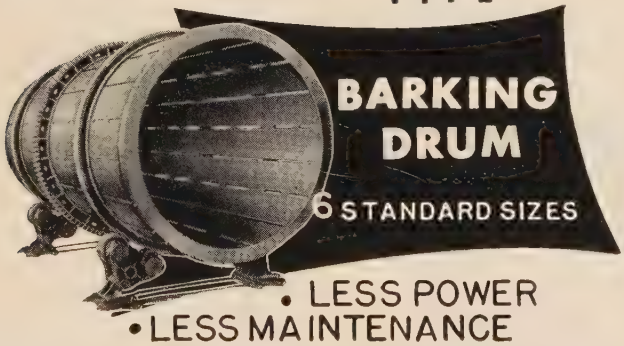
Ideal for use both in Labs and at points-of-process, you just flick the switch on your Brookfield Viscometer, read the dial and have your determination directly in centipoises.

High accuracy *plus* high sensitivity are inherent in the Brookfield principle of operation — direct indication through a calibrated spring of the torque on a rotating spindle.

Brookfield Viscometers are portable and plug into any ac outlet. Send for fully illustrated 1954 catalog listing all models and accessories. Also ask for special technical article on "Rheology of Paper Coatings." Write today to Dept. T.

Brookfield ENGINEERING LABORATORIES, INC. Stoughton, Mass.

MURCO PLATE-SHELL TYPE



• LESS POWER
• LESS MAINTENANCE
• LEAST BROOMING • CLEANER WOOD

The smooth interior of the MURCO plate-shell type barking drum, with or without sprays, delivers cleaner wood because there is only a minimum of bruising and brooming. In it true barking action comes from the friction of log against log, so there is no loss of wood and there is no dirt retention. Heavy duty rugged design, MURCO plate-shell type barking drum utilizes only a few lifters strategically located to stir the load occasionally to accomplish proper barking action.

Tell us the size, type of wood to be barked and production requirements . . . we will submit recommendations and complete proposal.

D. J. MURRAY MANUFACTURING CO.
Manufacturers Since 1883 • Wausau, Wisconsin

being made, using a deep-etched thin copper plate as a matrix.

Lloyd W. Conklin (U. S. pat. 2,598,761 (Oct. 10, 1952)) has a composition for rendering printing rollers nonmeltable. The compound consists of 1 part hexamethylenetetramine, 6 parts lanolin, and 2 parts glycerol. Any grease with a melting point below 90°F. can be used in place of lanolin. Any alcohol with a boiling point of 250°F. may be used for glycerin. Coat the roller and store for 30 days at 90°F., 55% relative humidity, to make the roller nonmeltable.

Fisher and Borden (U. S. pat. 2,610,939 (Sept. 16, 1953)), assigned to Riegel Paper Corp., have a compound or adhesive to be used in laminating glassine paper. It is composed of an amorphous wax 83%, a polymerized rosin 12%, a heavy viscous liquid polybutene 3%, and butyl resin 2%.

Printing Industries Equipment, Inc., New York, N. Y., have Glutofix 600XX, a wood cellulose product which mixes with cold water at a ratio of 1:50. The resulting paste is said to be odorless, colorless, flexible, and free from acid or alkali. It will not lump or clog and will retain its smoothness and consistency without deterioration over a long period.

National Adhesives Division of National Starch Products, Inc., have a new carton adhesive "Resyn 80N782" which can be used to precoat materials for specialty carton fabricators. The coating is said to seal and smooth a surface of rough, gray chipboard to produce at low cost a superior printing surface.

Monsanto Magazine 32, No. 4: 22–23, Aug.–Sept., 1953, states that the use of Chloramine T, a standard germicide, disinfectant, and deodorant is recommended as a bleaching agent in the restoration of books. The fine white powder dissolves in water and when applied to the page with a brush will remove foxing.

The Arnar-Stone Laboratories, 1316 Sherman Ave., Evanston, Ill., has a silicone ointment which prevents rough, chapped, and irritated skin resulting from frequent exposure to water and other substances.

RECEIVED June 15, 1954.

Fourth Testing Conference

of the

Technical Association

of the

Pulp and Paper Industry

Dayton-Biltmore Hotel, Dayton, Ohio

October 6–8, 1954

BECCO® BRIEFS

HIGH DENSITY PULP BLEACHING

Continuous hydrogen peroxide bleaching at 25-40% density is increasingly used for groundwood and chemical pulps in crumb or sheet form. High density operation has reduced chemical cost and floor area requirements. Groundwood bleaching is now more efficient than ever. Chemical and semi-chemical pulps are super-bleached to high brightness with improved aging characteristics not otherwise attainable. For detailed information write for Becco Bulletin No. 48.

Buffalo Electro-Chemical Company, Inc.

DIVISION OF FOOD MACHINERY AND CHEMICAL CORPORATION

Sales Agent: BECCO SALES CORPORATION, Station B, Buffalo 7, N.Y.
Buffalo • Boston • Charlotte • Chicago
New York • Philadelphia • Vancouver, Wash.

Edgar

SPRAY-SATIN

a new coating clay . . .

FINE FRACTION · SPRAY DRIED · HIGH QUALITY

a finer product for you

HIGHEST SHEET STANDARDS . . . demanded today by an increasing number of mills producing for quality conscious customers . . . were the reasons for the development of **SPRAY-SATIN** . . . an entirely new, but production proved, fine fraction coating clay.

Spray Drying - another Edgar First

For many years it has been known that the purest and most uniform clays could be produced by the "Spray Drying Method" . . . this is the same process used to make your morning's instant coffee. Many years of experimentation, development and commercial production by Edgar technicians have made "Spray Drying" a commercial success. The result is a new $750,000.00 plant expansion to provide you with the finest coating clay modern technology can produce.

try SPRAY-SATIN *in your own plant*

with these solid

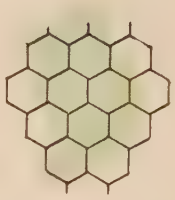
cost saving advantages

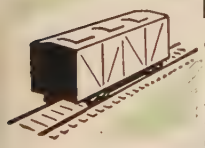
BONE DRY— Only with Spray Drying can you have a guarantee of less than 1% moisture without ever having the clay over-dried. In SPRAY-SATIN you will never find a pinhead . . . never a particle of calcined clay.

HIGHEST PURITY—In addition to finer than usual mechanical screenings, the spray drying process makes possible a magnetic screening of the slip to produce a purity of product never before achieved.

FREE FLOWING — EDGAR SPRAY-SATIN flows like sand. There is no caking, no arching in silos. Works wonderfully in airveyors and gravity flow systems. You will experience real cost savings in the handling of SPRAY-SATIN.

HIGH UNIFORMITY— Day in and day out and year in and year out, the spray drying process produces a product of unmatched uniformity. The precise controls of the spray drying method makes this high uniformity possible.





HIGH BULK DENSITY — Another unique advantage of the "Spray Drying Method" is a product of unusually high bulk density. For buyers who have storage problems, or who enjoy "incentive loading" freight rates, or who use covered hopper cars, there are substantial savings in the use of SPRAY-SATIN.

EASY MAKE-DOWN—Before the slip enters the final spray drying process a dispersant is added. You will find that SPRAY-SATIN will go into suspension almost immediately . . . make-down time is dramatically reduced.

Edgar Brothers Co.

METUCHEN, NEW JERSEY

Try a sample run of SPRAY-SATIN in your own plant . . . the product will prove itself.

EDGAR BROTHERS COMPANY, 13 STATION PLACE, METUCHEN, NEW JERSEY

Please send me, without obligation, sample as checked ⬡ 2 lb. ⬡ 5 lb. ⬡ 10 lb.

Name _____

Company _____

Address _____

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for economical REJECTS refining

DRYDEN PAPER COMPANY

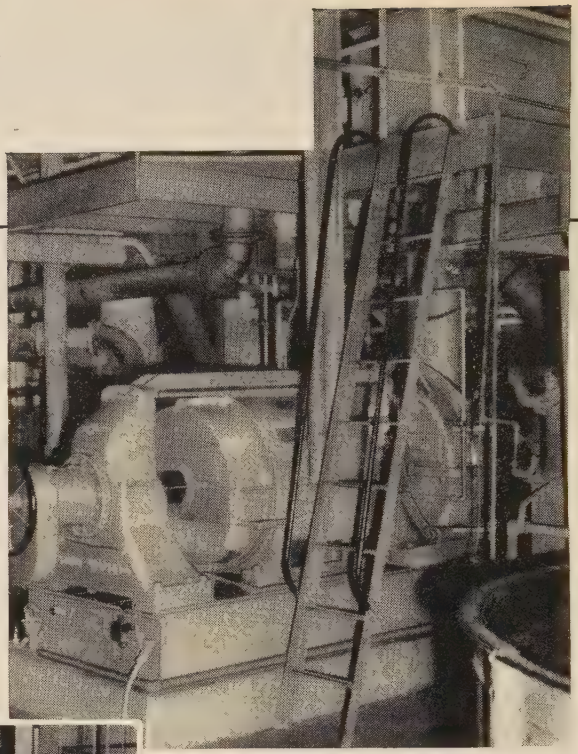
chooses a

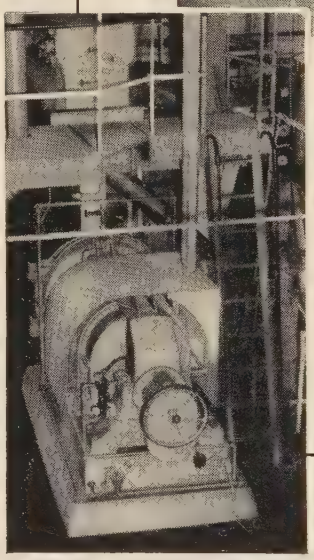
SPROUT-WALDRON

36-2 REFINER

and an S-W

FEEDING SYSTEM





The Sprout-Waldron 450 HP Refiner at Dryden Paper Company, Ltd., Dryden, Ontario refining kraft knots and rejects. A considerable reduction in horsepower requirements is reported over previous pulping, with much superior refined pulp quality. S-W offers refiners and efficient, complete feeding, conveying and dewatering equipment in one "package" . . . with one contract . . . one responsibility.

Single disc design, peripheral control ring and rugged construction for...

high pulp quality

flexibility of operation

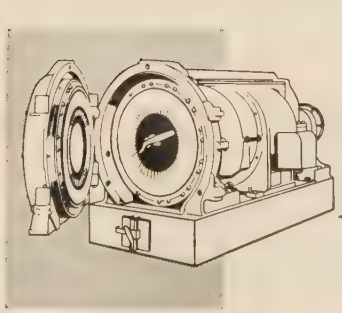
high capacity

low maintenance

The SPROUT-WALDRON refiner is the leading producer of high yield kraft pulp

For more information on semi-chemical pulping, or any other pulping application, send for our file of technical and practical data. Write to Sprout-Waldron & Co., Inc., 38 Logan Street, Muncy, Pa.

S W



for your pulping problem—

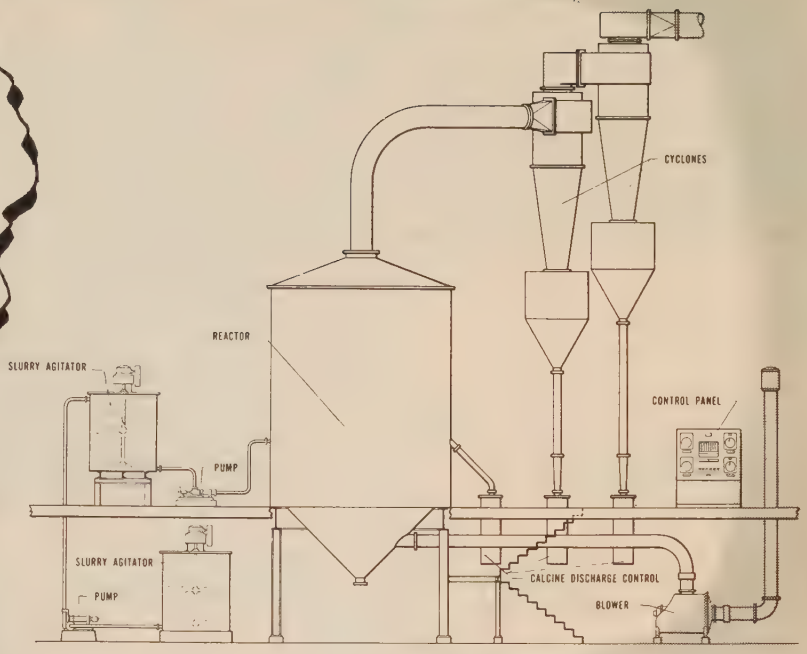
SPROUT-WALDRON

PULP REFINERS

362

Sulfite Pulp Producers

Are you satisfied with present methods for obtaining SO_2 for cooking liquor?



If a long term supply of elemental sulfur is meeting your acid requirements, you're probably more than satisfied.* But if high sulfur costs or seasonal interruptions in supply are a headache, a Dorrco FluoSolids System may be just the answer to your problem. Why? Because FluoSolids makes it possible to tap available supplies of pyrite, pyrrhotite and other sulfur bearing ores as an economically feasible and reliable source of high strength SO_2.

Tangible proof of FluoSolids' ability to deliver is the fact that seven Systems are now in operation, and two more are being installed in sulfite pulp mills, in the U. S., Canada and Norway for the production of SO_2 for their entire cooking liquor requirements. Eighteen more are in operation or being installed to produce SO_2 from pyrite, zinc and low grade sulfur ores at acid plants, which will produce over a million tons per year of H_2SO_4.

If you would like more information on FluoSolids — the most significant advance in roasting technique in the last 30 years — write for Bulletin No. 7500 to The Dorr Company, Stamford, Conn. or in Canada, The Dorr Company, 25 St. Clair Avenue East, Toronto 5.

*That is, if you're not bothered by weekend or other startups and shutdowns of the sulfur burner. If you are, the FluoSolids Process will also stand investigation. To shutdown an FS System it is only necessary to stop feeding and stop the blower. The fluidized bed subsides and the reservoir of heat is sufficient to bring the Reactor back to roasting temperature by simply starting the blower and feed. Reactors have been down for three days and started up again within half an hour without adding fuel.

FluoSolids is a trademark of The Dorr Company, Reg. U. S. Pat. Off.

Better tools TODAY to meet tomorrow's demand

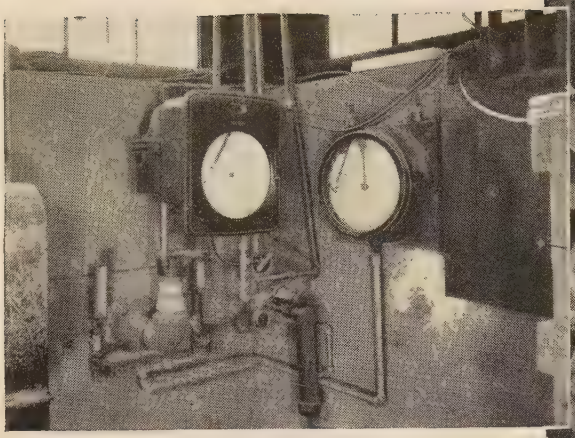
DORR

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

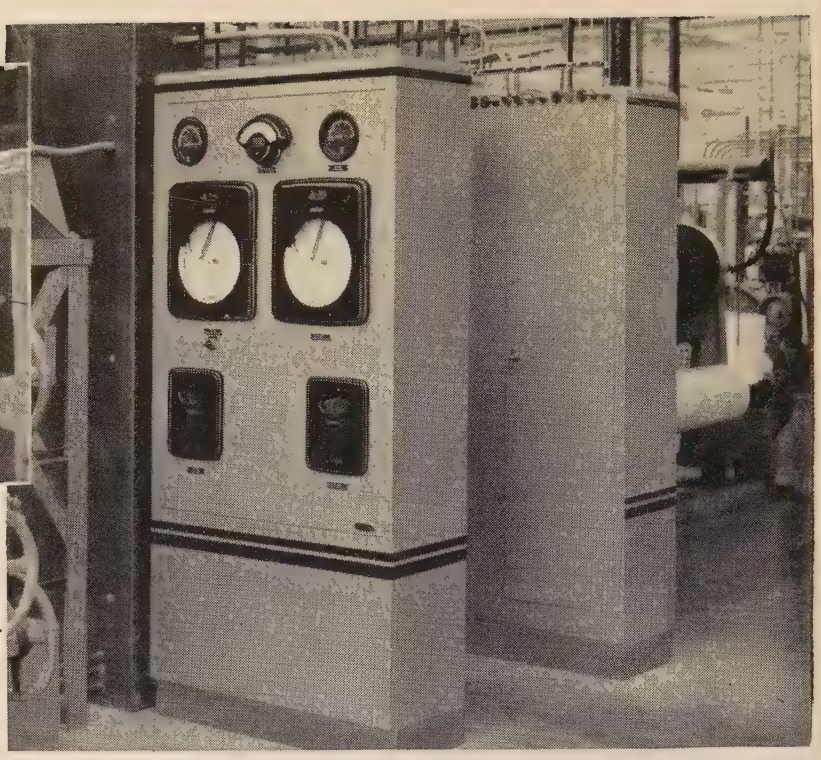
THE DORR COMPANY • ENGINEERS • STAMFORD, CONN.

Offices, Associated Companies or Representatives in principal cities of the world.

FIFTY YEARS of continuous progress 1904-1954



This is part of an old-fashioned installation which lacks the convenience and efficiency of modern instrumentation.

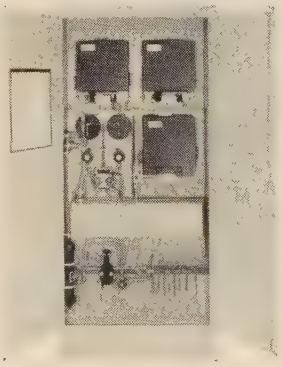


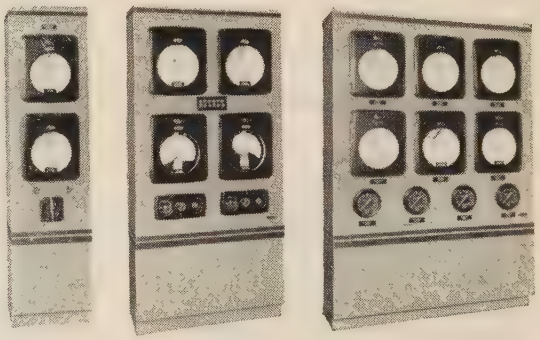
Compare this centralized Foxboro Cabinet installation of similar instrumentation, which saves time for the operator, makes his work more efficient, and gives maximum protection to the precision instruments required for his process.

See what a difference FOXBORO cabinet-mounting can make!

These photos show at a glance how much more efficient and attractive your instrument installation can be if it's integrated and centralized in a Foxboro Cabinet. Not only are the instruments protected from dust and process "atmospheres", but they're conveniently grouped together for more efficient use and easier maintenance. Those "endless steps" of the operator are a thing of the past!

Foxboro will supply a cabinet (or cabinets) to house and protect any number of existing instruments and related devices. Or your order for new instruments can be shipped to you already mounted in cabinets, completely piped and wired, needing only simple power and process connections to be put into operation. Write for illustrated and informative Bulletin 413.





Foxboro Cabinets are available in three standard sizes for 2, 4, or 6 conventional-size instruments (or equivalent). For mounting more than 6 instruments, Foxboro Sectional Cabinets (with open ends) are used . . . bolted together to form desired length. End sections have one closed side to form dust-tight enclosure. Exclusive insert-type panel construction permits easy conversion when process changes so require.

THE FOXBORO COMPANY, 787 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.

FOXBORO REG U S PAT OFF

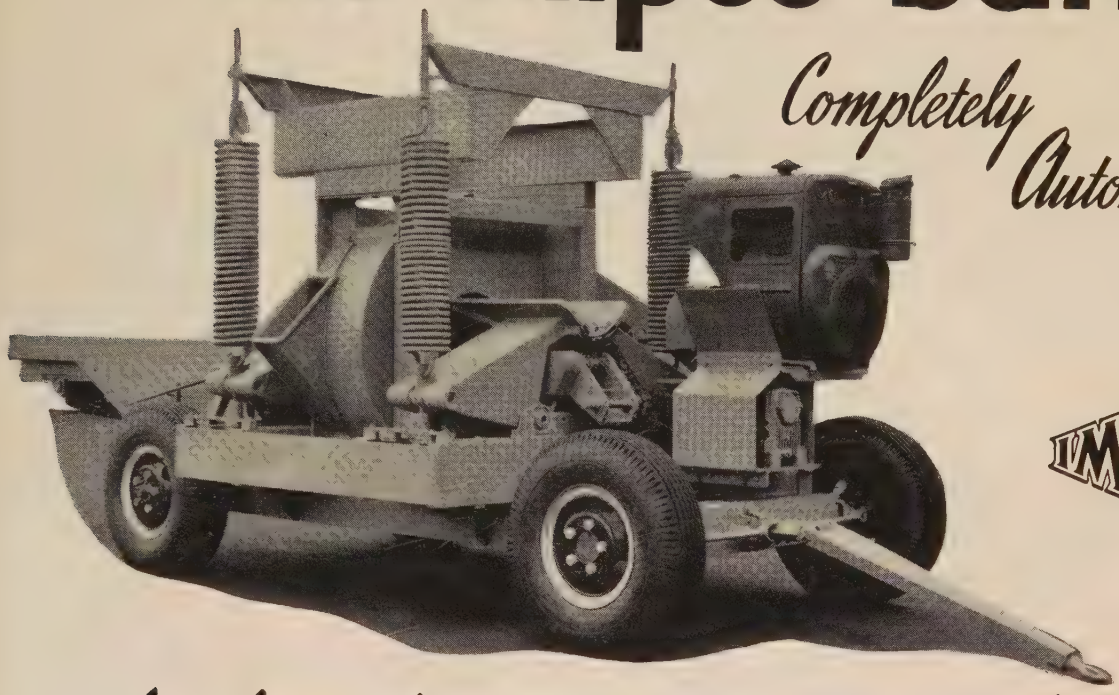
PROCESS CONTROL CABINETS

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Introducing

the Impco barker

Completely Automatic



IMPCO

Easily handles irregular shaped logs!

The Impco Barker has been developed to meet day's high bark removal requirements combined with w wood loss.

It is available as a stationary unit for general wood rd barking or as a portable unit mounted on a heavy ame equipped with tires for highway towing. The obile unit can be furnished with a self-propelling drive r moves between barking sites.

Capacities up to 20 cords per hour depending on nditions, size and type of wood can be expected.

Specifications:

Wood size—
4′ to 8′ in length, 4″ to 18″ in diameter
Feed Rate—
30 to 120 f.p.m.
Infeed and Outfeed Conveyors—
Automatic self-centering self-sizing
Barking Tools—
6 springloaded—automatic sizing for variable log diameters
Bark Discharge—
Mechanical ejection
Drives—
Gasoline or electric powered

MPROVED
MACHINERY INC.
SHUA • NEW HAMPSHIRE

erbrooke Machineries Limited, Sherbrooke, Quebec, manufacture similar equipment in Canada

F 1-a

production increased up to 15 tons per day...

. . . with W & T chlorination equipment

A Southern mill had been having trouble with paper breaks attributable to the presence of slime in their white water. Despite continued efforts to control them slime breaks were running 60 to 80 per week, resulting in a time loss of 10 to 14 hours per week, and an average production loss of 15 tons per day! It was then that the W&T man was called in. Where and how to apply the proper treatment was determined, the costly methods were discontinued, and W&T chlorination was installed.

During the first 3 days of chlorination the mill recorded only 1 slime break and 2 minutes of lost time.

During the next 3 days there were 4 breaks and 17 minutes of lost time.

During the next 25 days there were no breaks attributable to slime!

. . . Within a week there were no production losses caused by slime! Performance such as that is typical of what your W&T representative can do for you.

If you have a production problem attributable to impure water, it would pay you to write or call him now.

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

I-42

increase the **densometer** of your **fourdrinier** board

■ Kelgin in your sizing formulations will increase densometer of Fourdrinier paper and paperboard without adverse effect on other paper qualities. **Check these advantages:** **1.** Improved smoothness and finish **2.** More uniform printing surfaces **3.** Greater wax, oil and varnish resistance **4.** Control of porosity

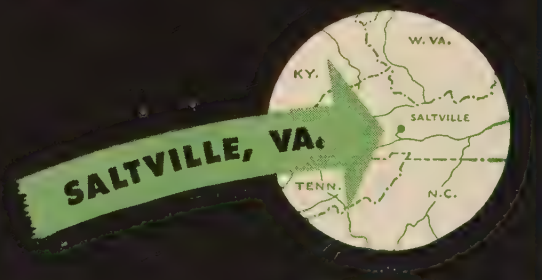
It takes fine felts to make fine paper

Whatever Your Paper Problem . . . It's a Challenge to Champion!

SHULER & BENNINGHOFEN, HAMILTON, OHIO

Multi-plant facilities multiply your safety

From Quebec to the Gulf, Mathieson shipping points form a chlorine supply line serving the major industrial areas of the East, South, and Midwest. At Mathieson, your chlorine source is backed up one or more times to assure dependable supply and reliable delivery schedules.

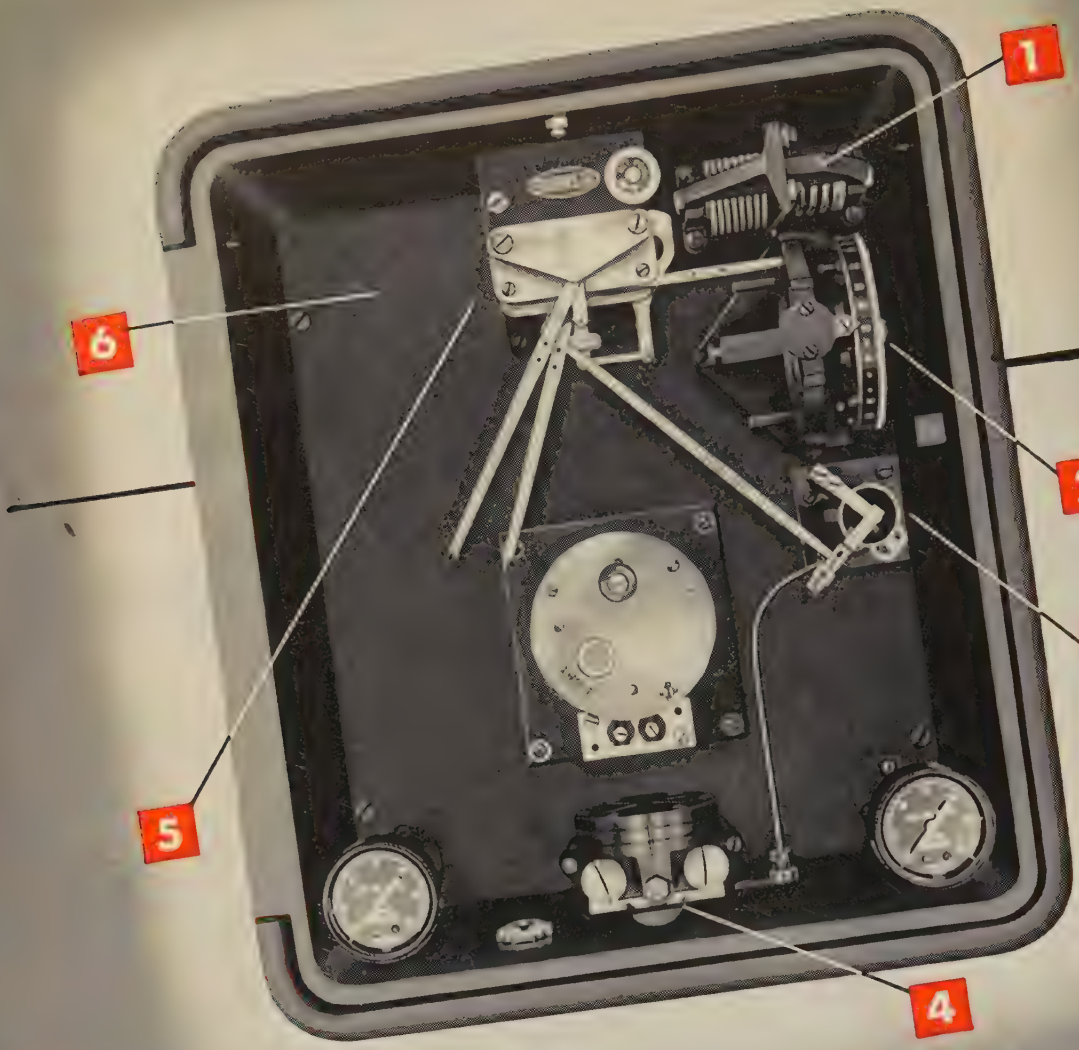


Supply safety is another Mathieson PRODUCT-PLUS of significance to the chemical process industries. Quality chemicals, PLUS practical technical assistance, PLUS plants and shipping points in key industrial areas, add up to why you can buy chemicals to better advantage from Mathieson.

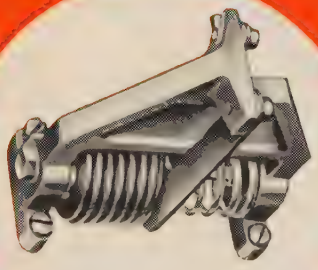
MATHIESON CHEMICAL CORPORATION
Mathieson Industrial Chemicals Division
Baltimore 3, Maryland

caustic soda • soda ash • chlorine • sulphur • sulphuric acid • bicarbonate of soda • ammonia • sodium nitrate • nitric acid • sodium methylate sodium chlorite • hypochlorite products • dry ice and carbonic gas ethylene glycols and oxide • methanol • sulphate of alumina

2306

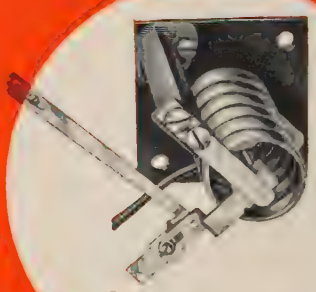


MASONEILAN 60000 SERIES PNEUMATIC CONTROLLER



1. PROPORTIONAL UNIT
interchangeable with proportional-reset unit.

2. GIMBAL UNIT
combines primary and feedback motions — basic in all controllers.



3. PRIMARY ELEMENT
helical or spiral bourdon, or bellows as required.

A HIGH Cq (Quality Coefficient) PRODUCT

Instrument Man's Instrument

MASONEILAN

Masoneilan 60000 Series Controller IS SIMPLE AS A B C

One Setting of basic "3-in-1" controller

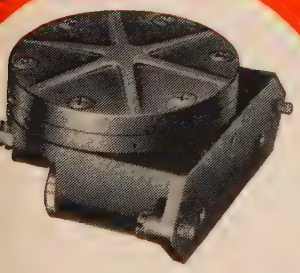
selects on-off, proportional, or differential-gap control; direct or reverse action; proportional band or differential-gap setting.

Easy to Set, Adjust, Test and Service —

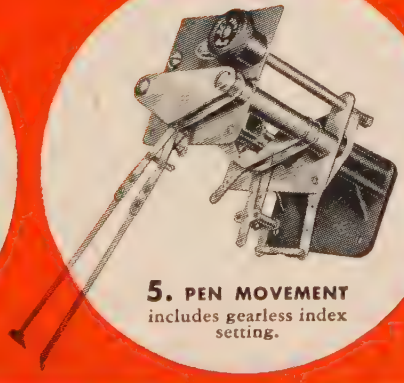
all settings made without removing chart; all subassemblies complete and directly accessible; all air passages manifolded; four-position transfer switch in manual control subpanel.

Easy to detach and interchange subassemblies

from backplate-manifold to vary desired control function; for cleaning or servicing.



4. RELAY PILOT
with cleanable orifice and integral filters.



5. PEN MOVEMENT
includes gearless index setting.

6. BACKPLATE-MANIFOLD
supports subassemblies; conceals, supports, tubing; eliminates fittings.
(Rear View)

MASON-NEILAN REGULATOR CO.

1207 ADAMS STREET, BOSTON 24, MASS., U. S. A.

Sales Offices or Distributors in the Following Cities:

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Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham • New Orleans • Dallas • Seattle
Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

Dependable Source for Chemical Raw Materials

Richard T. Trelfa (left), technical director, discusses test results with H. S. Faram, quality control manager, Watervliet Paper Company, Watervliet, Michigan

"Over the years, we've found Wyandotte Chemicals an excellent source of supply"

—R. T. Trelfa, Watervliet Paper Company

Papermaking is a two-phase job. You have to produce a top-quality stock, within practical bounds of cost, to insure saleability. And, equally important, you must be on the lookout for new ideas and methods to keep pace with progress.

The operations of the Watervliet Paper Company, Watervliet, Michigan, are a good example of modern papermaking efficiency. Quality is controlled every step of the way. This, of course, includes the quality of materials purchased, like Wyandotte Caustic and Chlorine. They use caustic in treating waste paper; chlorine is needed in pulpmaking and bacteria control.

With an eye to the future, Watervliet has established the country's first mill to produce a fully bleached, neutral sulphite, semi-chemical pulp from hardwood. Furthermore, they have pursued an active course of co-operation with Wyandotte's research. Some of the joint activities have been detailed engineering on soda-based hypochlorites, and the application of fine calcium carbonates to paper finishes.

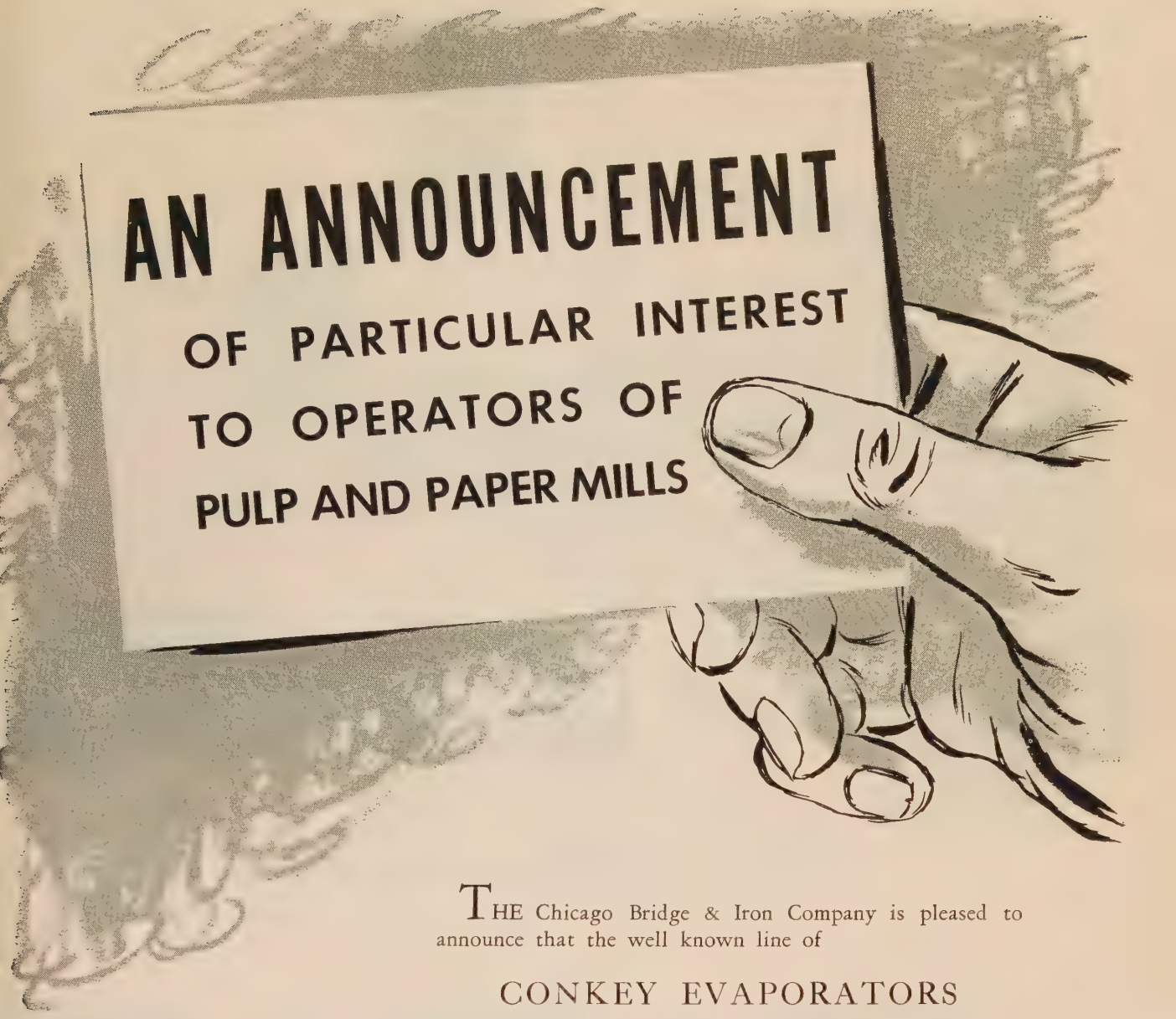
Commenting on Wyandotte products and service, R. T. Trelfa, Watervliet's technical director, says, "Over the years, we've found Wyandotte an excellent source of supply from the standpoint of both product quality and dependability of service."

If you use alkalies, chlorine, wetting agents, solvents, fumigants, insecticides or other chemicals, contact Wyandotte for either product data or technical service. You will find Wyandotte large enough to care for your needs, yet not too large to be interested in your day-to-day problems. Tell us your requirements . . . we may have a chemical that will satisfy your needs, or will work with you in developing a new one. May we serve you. *Wyandotte Chemicals Corporation, Wyandotte, Michigan. Offices in principal cities.*

Wyandotte
REG U S PAT OFF
CHEMICALS

HEADQUARTERS FOR ALKALIES

Soda Ash • Caustic Soda • Bicarbonate of Soda • Chlorine
Calcium Carbonate • Calcium Chloride • Glycols • Synthetic Detergents • Agricultural Insecticides • Soil Conditioners
Other Organic and Inorganic Chemicals



THE Chicago Bridge & Iron Company is pleased to announce that the well known line of

CONKEY EVAPORATORS

now extensively used in pulp and paper mills, will in the future be fabricated in CB&I's plants.

A sales and engineering office, staffed by Conkey Equipment personnel will be maintained at 165 Broadway, New York 6, N. Y.

Since both Chicago Bridge & Iron Company and the Conkey personnel have been closely associated with the pulp and paper industry for many years, the combination is ideal to insure proper design, fabrication and erection of CONKEY EQUIPMENT.

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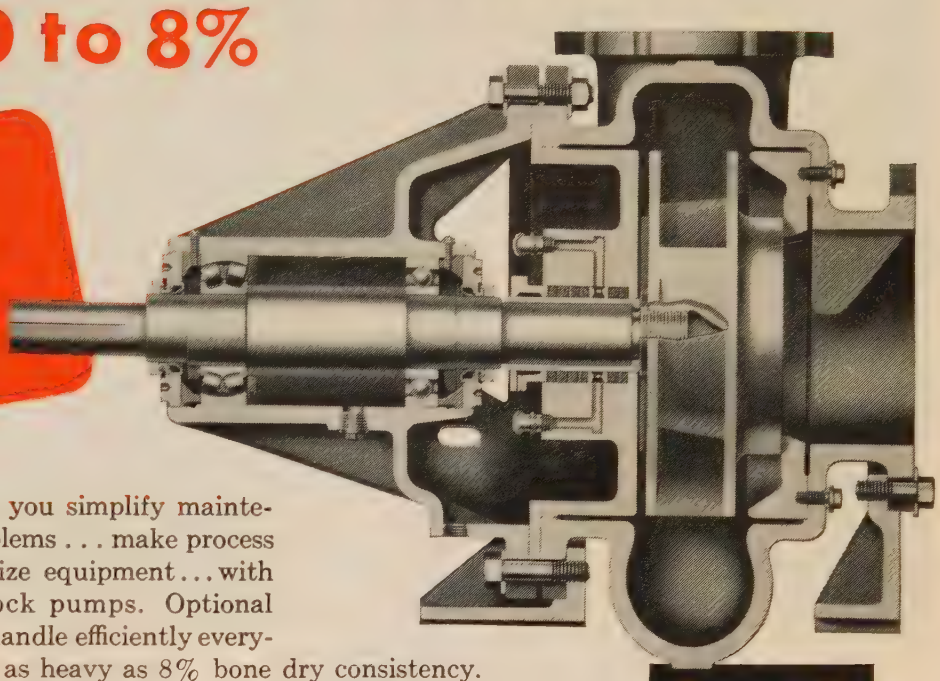

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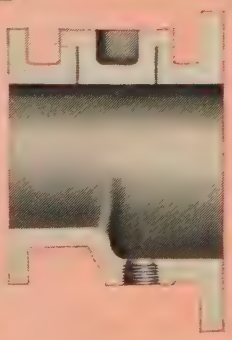

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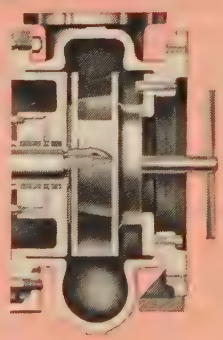

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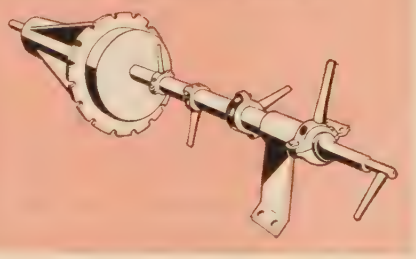

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Cellulose Solvents for Viscosity Measurements

The Effect of Copper and Base Concentrations in Cuprammonium and Cupriethylenediamine Solutions

B. L. BROWNING, L. O. SELL, AND WM. ABEL

Copper-base solutions covering the composition ranges of 7.5 to 35 g.p.l. (grams per liter) of copper and with 125 to 250 g.p.l. of ammonia or 50 to 150 g.p.l. of ethylenediamine have been examined as solvents for cellulose. Cuprammonium solutions containing more than 30 g.p.l. of copper or 200 g.p.l. of ammonia are not stable enough for practical use. If the copper concentration exceeds 10 g.p.l., sucrose is necessary to stabilize the solution, and decomposition at 23° then occurs only slowly. In qualitative tests, chemical cotton and a rayon pulp dissolved completely in all the cuprammonium solutions containing 10 g.p.l. or more of copper, but a high-polymer cotton and bleached semichemical pulp left some undissolved residues unless the solutions contained 25 to 30 g.p.l. of copper. Cupriethylenediamine solutions dissolved cellulose only if the base-copper molar ratio was within the range of 2:1 to 3:1, and the copper content was 0.5 to 1 *M*. The specific viscosities of celluloses in cuprammonium solutions are markedly decreased by increase in ammonia contents over the range of 98 to 176 g.p.l., and are affected only slightly by copper contents over the range of 14 to 28 g.p.l. The compositions of cupriethylenediamine solutions which dissolve cellulose satisfactorily are rather limited, and the TAPPI solvent 1 *M* in base and 0.5 *M* in copper was the best of the solvents tested. The specific viscosity decreases markedly as the copper concentration is increased from 0.5 to 1.0 *M*, with the base-copper ratio of 2:1. Increase in the base-copper ratio generally increases the specific viscosity. Tests on chemical cotton showed that the intrinsic viscosity is dependent upon the copper and base concentrations used in the solvent. However, no feasible concentrations of cuprammonium and cupriethylenediamine solutions were found which would yield identical values for the specific viscosity in the two solvents.

Measurements of viscosity have been used for many years for the characterization of cellulose preparations. In some methods the cellulose is dissolved directly in a solvent, while in others the cellulose is converted into a derivative which is then dissolved in an appropriate solvent. There are few solvents which can be used for dissolving cellulose without severe concomitant degradation. In practice, they have been limited to copper-base solvents, phosphoric acid and some of the substituted ammonias such as dimethyldibenzylammonium hydroxide.

The copper-base solvents have found wide application as direct solvents for cellulose, and the bases have been chiefly ammonia and ethylenediamine. The cuprammonium solvents have included a variety of compositions. Those commonly used are represented by TAPPI Standard T 206 m, 15 g.p.l. of copper and 200 g.p.l. of ammonia and by the American Chemical Society method (*1*) and its modifications, 30 g.p.l. of copper and 165 g.p.l. of ammonia. The cupriethylenediamine method is represented by TAPPI Suggested Method T 230 sm-50, in which the copper concentration of the dissolving solution is 0.5 *M*, and the ethylenediamine is approximately 1 *M*.

It is evident that the user has a choice of solvent, cuprammonium or cupriethylenediamine, and in the former a choice of compositions. The lack of a uniform method in the industry leads to a possible diversity of viscosity values for a single material. Also, despite the very extensive study and widespread use of both copper-base solvents, the limitations on copper and base concentrations are not clear, and the optimum concentration of copper and base in either solvent may not have been achieved. Moreover, present opinion is sharply divided as to the relative merits of ammonia and ethylenediamine as the base.

These considerations led the joint TAPPI-ACS-ASTM Disperse Viscosity Subcommittee to request that experimental work be undertaken to secure some additional background information which might be helpful to the Committee in the revision of viscosity methods. The present study was designed to explore the effects of copper and base concentrations in cuprammonium and cupriethylenediamine solvents on the solubility of cellulose from various sources and on the specific viscosity of the dissolved cellulose.

PREVIOUS WORK

The action of ammoniacal copper solutions on cellulose seems to have been first observed by Mercer (*2*), although their use for dissolving cellulose is usually attributed to Schweizer (*3*). The early applications of such solutions for technical purposes has been reviewed by Worden (*4*).

The application of cuprammonium (cupram) solutions of cellulose for measuring viscosity as a diagnostic test is usually credited to Ost (*5*) in 1911. The solutions used by Ost contained 13 to 14 g.p.l. copper and about 200 g.p.l. ammonia, and were prepared by dissolving basic copper sulphate in aqueous ammonia. Solutions of approximately the same composition were used by Gibson, Spencer, and McCall (*6*) and by Joyner (*7*). However, the presence of sulphate was found undesirable, and they prepared cupram solutions by dissolving cupric hydroxide in aqueous ammonia or by air oxidation of metallic copper in ammonia solutions.

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This work was sponsored by the Chemical Methods Committee for the joint TAPPI-ACS-ASTM Disperse Viscosity Subcommittee under the chairmanship of A. F. Martin, and represented TAPPI Research Grants Nos. 26 and 45.

Farrow and Neale (*8*) prepared solutions by electrolysis of ammonia solutions with copper electrodes, and adjusted concentrations to 15 (14.8 to 15) g.p.l. copper and 240 (236 to 245) g.p.l. ammonia. The same concentrations were used by Clibbens and Geake (*9*), but it was found that the method of Farrow and Neale gave solutions of too high a nitrite content and so the air oxidation method of Joyner was adopted. The method described by Clibbens and Geake found wide use at the Shirley Institute in England, and was later adopted with minor modifications as the TAPPI and ASTM Standards.

Meantime, in this country, some of the laboratories interested in the processing of cotton had developed methods using cupram solutions of 30 g.p.l. copper and 165 g.p.l. ammonia (*10, 11*). The solutions of high copper concentration were considered necessary for dissolving high viscosity cottons, and could be prepared readily by the air oxidation method of Joyner, when 10 g.p.l. sucrose was added as stabilizer. This work led to establishment of the standard method of the American Chemical Society (*1*) which with some modifications still enjoys widespread use.

A number of investigators have reported that the copper and ammonia concentrations of cupram solutions affect the dissolving properties of the solution and the viscosity of the dissolved cellulose. In general, the ammonia concentration has a much greater effect than that of copper.

Gibson *et al.* (*6*) found variable viscosity results because of variation in copper and ammonia concentrations when the solutions were prepared according to Ost. The viscosity of a 2% solution of cotton varied from 1.64 poises with copper 8.47 and ammonia 266.9 g.p.l. to 5.44 poises as the copper was increased to 28.40 and the ammonia decreased to 129.7 g.p.l. The first thoroughgoing study was that of Joyner (*7*). He studied the viscosities of cotton cellulose at several concentrations with a series of solvents in which the ammonia content was 210 g.p.l. and the copper content varied over the range 6.0 to 29.4 g.p.l. At lower copper concentrations a change in concentration had a considerable effect on viscosity but this effect was much decreased as a concentration of 30 g.p.l. was approached. Changes in ammonia content from 92 to 235 g.p.l. with copper 24 g.p.l. and from 60.5 to 212 g.p.l. with copper 13.5 g.p.l. gave results which showed a marked effect of ammonia concentrations, in which the logarithm of the viscosity was proportional to the ammonia concentration. Arkhipov (*12*) stated that an increase in the copper content from 11 to 14 g.p.l. at ammonia concentrations of 151 to 220 g.p.l. results in a decrease in the viscosity, whereas at a constant copper content the viscosity decreases as the ammonia increases from 151 to 201 g.p.l. but increases when the ammonia is raised to 220 g.p.l. It was noted that the time of stirring to reach maximum viscosity depends upon the copper and ammonia concentrations.

Hisey and Brandon (*13*) carried out tests at cellulose (cotton linter) concentrations of 0.25 to 1.5%, and with cupram solvents of 200 g.p.l. ammonia and 10, 15, 20.1, and 22.4 g.p.l. copper. The change in viscosity for an increase in copper of 1 g.p.l. varied from +0.92 to −1.32%, depending upon the pulp concentration. With the copper concentration constant at 15 g.p.l., increases in ammonia concentration over the range of 152 to 225 g.p.l. resulted in a decrease in both absolute and relative viscosities for all the cellulose concentrations above 0.25%, with the percentage change per gram change in ammonia varying from 0.09 to 0.70. Launer and Wilson (*14*) found no difference in degree of polymerization when the copper varied from 10 to 18 g.p.l. but pointed out that the effect of copper may be greater at cellulose concentrations greater than the 0.5 g.p.l. which they used.

The application of copper-ethylenediamine solutions as solvents for cellulose is based on the observations of Traube (*15*). Successful application of cupriethylenediamine (cuprien) solutions for viscosity measurements was made by Straus and Levy (*16*) and by Hatch (*17*). No extensive study of different solvent compositions has been reported. Straus and Levy (*16*) stated that a solution 0.5 *M* in copper is a suitable solvent for all types of cellulose whose viscosity can be determined by the TAPPI cuprammonium method, and that 1 *M* copper solutions are less stable but are better solvents for high viscosity celluloses. They used solutions saturated with cupric hydroxide and found that the base copper ratio was 2:1 regardless of dilution. Further, they reported that even small amounts of amine in excess of the 2:1 ratio markedly decrease the solubility of cellulose, and that when the ratio reaches 2.25 to 1 the solution completely loses its solvent power. Hatch (*17*) reported that an increase in base above the 2:1 ratio gives high viscosity results.

McLean and Walker (*18*) varied the base-copper ratio from 1.73 to 3.12 and reported that the viscosity increased markedly as the base concentration increased. They found that the solubility of cellulose was much less affected by excess base than had been indicated by Straus and Levy. Almin (*19*) found that base-copper ratios from 1.80 to 2.10 gave essentially constant specific viscosity of linters, but his solutions contained sodium chloride and the cellulose concentration was lower than that usually used.

EXPERIMENTAL

In the initial phase of the work, solutions covering wide ranges of copper and base concentrations were examined with reference to the possibility of preparing solvents, stability of solvents under practical storage conditions, and dissolving power of the solvents toward a variety of celluloses. The second portion of the work embodied a more intensive study of the effect of copper and base concentrations on the specific viscosity of the dissolved celluloses.

Apparatus

In order to permit dissolving cellulose in an oxygen-free atmosphere, all solutions were prepared in 60-ml. serum bottles, fitted with pull-over type rubber stoppers. The bottles were flushed with nitrogen and dissolving solution was introduced through a no. 18 syringe needle inserted into the stopper. The apparatus used is shown schematically in Fig. 1.

The desired quantity of cellulose was weighed into the serum bottle, and the stopper was inserted. The bottle was then connected to the apparatus by piercing the stopper with the needle. The bottle was alternately evacuated by a water pump and filled with

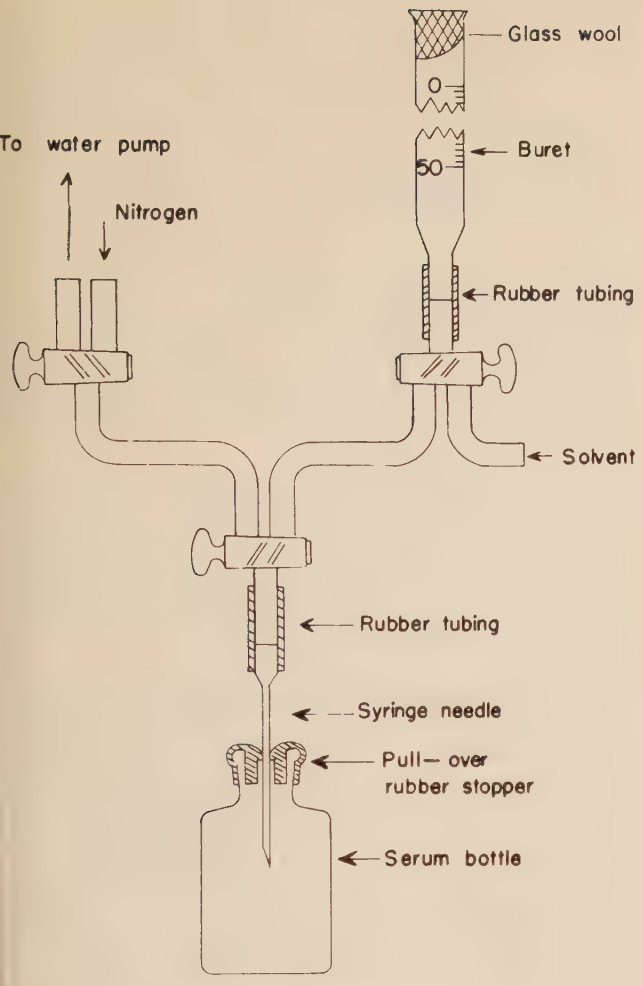

Fig. 1. Dissolving bottle and apparatus for filling

purified nitrogen three times. It was evacuated once more, the dissolving solution was introduced from the buret, and nitrogen was again admitted until a slight positive pressure existed in the bottle. The bottle was wrapped to exclude light during the dissolving period. The bottles were shaken (usually in an upright position) in a horizontal reciprocating shaker operating at approximately 200 oscillations per min. and with an approximately 1-in. stroke.

The nitrogen used was of prepurified grade, and to remove any residual oxygen it was passed over copper turnings heated by a long burner in a Vycor microcombustion tube at approximately 900°C.

Cellulose Samples

Five cellulose samples were procured for use throughout the work. They were chosen to represent a variety of celluloses of diverse origin and to be typical of materials to which a viscosity method might reasonably be applied.

1. A high-polymer cotton, supplied by the Southern Regional Research Laboratory. This was a sample of loose-twist Iquitos cotton in skein form. The product had been extracted with hot 95% ethyl alcohol to remove the natural wax and then washed out with two changes of hot water and air dried. It was prepared for test by cutting threads into short lengths, which were reduced to a fluffy form by a brief treatment in dry form in a Waring Blendor.

2. A chemical cotton, cottonseed hull shavings pulp, grade 7. It was supplied by the Virginia Cellulose Department of the Hercules Powder Co. and was in a fluffy form requiring no further defibering.

3. A rayon pulp (Rayaceta) sent from the Experiment Station of the Hercules Powder Co. It was fluffed when received and was not further treated.

4. A bleached semichemical pulp. It was pulped to a permanganate number of 37.0 as a part of commercial production. The pulp was alternately chlorinated and alkali extracted by the laboratory of the Hercules Powder Co. The final permanganate number was 0.4, and the pulp contained 82.4% alpha-cellulose and 19.6% pentosans. The pulp was passed through a Wiley mill fitted with a 20-mesh exit screen.

5. A high viscosity commercial bleached flax pulp. The pulp was prepared for testing by washing successively with water and benzene, and air drying. The "threads" were given a brief treatment in dry form in a Waring Blendor to reduce the pulp to a more workable fluffy form.

Determination of Intrinsic Viscosities

The intrinsic viscosities of the four celluloses were determined at the beginning of the work as a guide for choosing concentrations to be used in solution tests. The ACS solvent was used for the high-polymer cotton, a solution of 25.3 g.p.l. copper and 152 g.p.l. ammonia for the flax pulp, and the TAPPI solvent for the remaining three samples. Cannon and Fenske viscometers were used. The two arms of the viscometers were connected by gum rubber tubing. By inserting the syringe needle into the tubing, the viscometers were flushed and filled with nitrogen and, the solution under test was transferred from the dissolving bottle to the viscometer by a hypodermic syringe. After temperature equilibration in a bath at 25°C., the flow time was determined.

The viscosities were determined at several concentrations, and the specific viscosities were calculated in the usual manner. The reduced viscosities were plotted against the concentrations on semilogarithmic paper in accordance with application of the Martin equation. The plotted data are shown in Fig. 2. The intrinsic viscosity values obtained by extrapolation are:

High-polymer cotton	17.2
Chemical cotton	9.2
Rayon pulp	6.4
Bleached semichemical pulp	5.5
Flax pulp	8.8

Stability and Dissolving Power of Cuprammonium Solutions

Since a large number of solutions were required to cover the desired ranges of copper and ammonia concentrations, it was found convenient to prepare the individual solutions from a relatively few carefully analyzed master solutions. The required volumes of master cupram solutions, ammonium hydroxide solutions, and water were added to 100-ml. flasks and diluted to volume.

A cupram solvent was prepared according to the method given in TAPPI Standard T 206 m-44, but without addition of sucrose. Test solutions made from this stock solution containing 14.7 to 18.6 g.p.l. of copper and 194 to 248 g.p.l. of ammonia, decomposed with precipitation of cupric hydroxide in 9 days or less at approximately 15°C. Similar test solutions decomposed within 1 month at 23°C. if the copper concentration was 11 g.p.l. or greater. The solutions containing 10 g.p.l. or less of copper were stable for periods of 4 months or more. Solutions containing in excess of

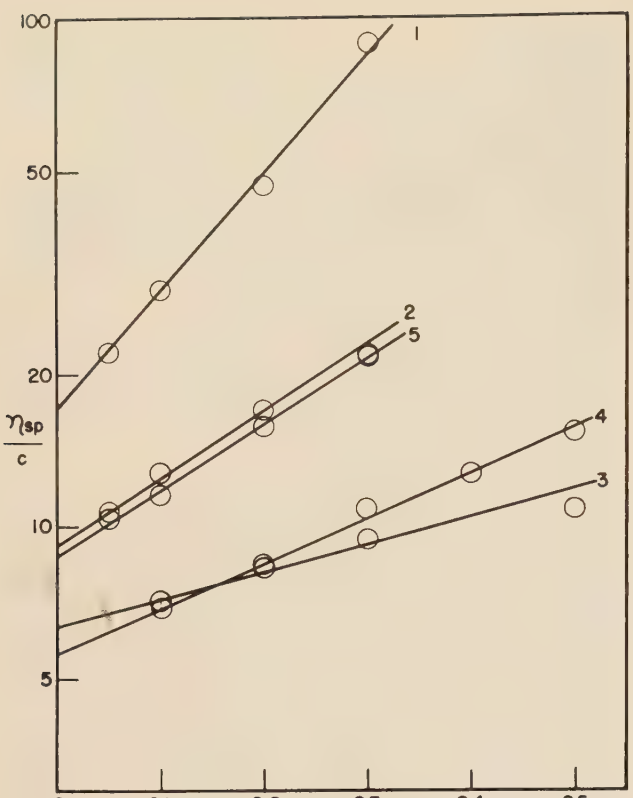

Fig. 2. Intrinsic viscosities of the celluloses

(1) High-polymer cotton. (2) Chemical cotton. (3) Rayon pulp. (4) Semichemical pulp. (5) Flax pulp.

10 g.p.l. of copper and no sucrose appear to be unstable irrespective of the ammonia concentration.

Further tests on unstabilized solutions were carried out with solvents of approximately the ACS concentration. A solution containing 34.8 g.p.l. of copper and 183 g.p.l. of ammonia was prepared at low temperature, but cupric hydroxide was precipitated even at 0°C., and a solvent of ACS composition decomposed within minutes at 20°C. Portions of this solution diluted to 12.5, 15, 17.5, 20, and 25 g.p.l. of copper and 125, 150, 167.5, 175, and 200 g.p.l. of ammonia were stable for no more than a few days at 5°C.

Because it was evident that unstabilized cupram solutions containing copper in excess of about 10 g.p.l. of copper do not meet minimum stability requirements, solutions of higher concentrations were stabilized with sucrose. The following stabilized solutions were prepared: (1) 15 g.p.l. of copper, 200 g.p.l. of ammonia, 2 g.p.l. of sucrose; (2) 35 g.p.l. of copper, 125 g.p.l. of ammonia, 10 g.p.l. of sucrose; and (3) 35 g.p.l. of copper, 250 g.p.l. of ammonia, 10 g.p.l. of sucrose. These stock solutions were mixed or diluted with ammonium hydroxide and water, as required, to prepare test solutions of the desired concentrations. The use of a nomographic chart permitted selection of the desired volumes without calculation. Because of the method of preparation, the test solutions did not contain the same quantity of sucrose. It is possible that additional sucrose would have resulted in greater stability of some solutions.

The stability tests on cuprammonium solutions are shown in Fig. 3. Those for copper concentrations of 10 g.p.l. and less represent unstabilized solutions. All solutions of higher copper concentrations contained added sucrose. The stability of solutions was judged by the absence of precipitated material after storage for 30 days at 23°C.

Solutions containing sucrose as a stabilizer are fairly stable at all concentrations of copper up to 35 g.p.l. and at ammonia concentrations of from 125 to 250 g.p.l. if the solutions are stored at about 5°C. At 23°C. slow separation of cupric hydroxide or oxide occurs at the higher copper concentrations. Cuprammonium solutions without the addition of sucrose as stabilizer do not meet minimum stability requirements if the copper concentration is above about 10 g.p.l. Solutions containing 35 g.p.l. copper were markedly unstable, irrespective of ammonia content, even when considerable sucrose was present. Solutions containing 225 and 250 g.p.l. ammonia were difficult to handle because of the higher partial pressure of ammonia, and they did not appear to possess any marked advantages in either stability or dissolving power for cellulose.

For testing the dissolving power of the solvent, a concentration of cellulose was used such that the product of the intrinsic viscosity and concentration (grams per deciliter) equaled 10. Since Martin has suggested values of 5 (*20*) and later of 3 (*21*) for this product, the value of 10 represents a maximum concentration which might be used in his proposed viscosity method. The cellulose concentrations in grams per deciliter used for testing were: high-polymer cotton 0.58, chemical cotton 1.09, rayon pulp 1.56, semichemical pulp 1.82. The desired quantity of cellulose was introduced into the dissolving bottle, and cuprammonium was added in an oxygen-free atmosphere. The bottles were protected from light and shaken for 16 hours. The sole criterion applied was the completeness of solution of the cellulose, and no viscosity determinations were made.

The extent of solution of a given cellulose was described in the following ways:

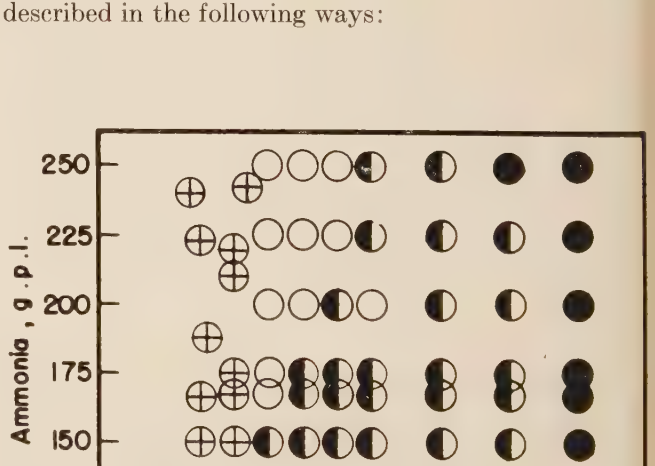

Fig. 3. Stability of cuprammonium solutions

⊕ Stable without sucrose. ○ Stable with added sucrose. ◐ Slightly unstable with sucrose present. ● Very unstable with sucrose present.

1. The cellulose was considered insoluble if undissolved fibers ould be seen readily, and the solution had developed little if ny added viscosity.
2. The cellulose was considered partly soluble if the fibers ad largely lost their identity and the solution exhibited a fairly igh viscosity, but fiber fragments or residues could be identified nder low-power magnification.
3. The cellulose was considered soluble if examination under w-power magnification yielded no appreciable quantity of lentifiable fiber fragments.

It was found that the microscopic examination could e quite suitably carried out in an improvised cell of he following design. A piece of no. 26 (B. & S. gage) opper wire was bent into the shape of a large U in- erted between two microscope slides. The wire served ne dual role of film thickness spacer and oxidation inhibitor. The two slides were clamped together with four pieces of rubber tubing (3-mm. bore, 2-mm. wall) which had been slit along one side and cut exactly to fit the edges of the microscope slides. In use, one of the tubes was removed from the slides, and the U-shaped cavity filled with the solution from a hypodermic syringe. The assembly permitted retention of the sample for observation over a period of several hours without apparent alteration. A slight pressure on the top slide gave just sufficient movement of the solution to assist in the observation. It was found convenient to use a Greenough binocular microscope at approximately 30× magnification.

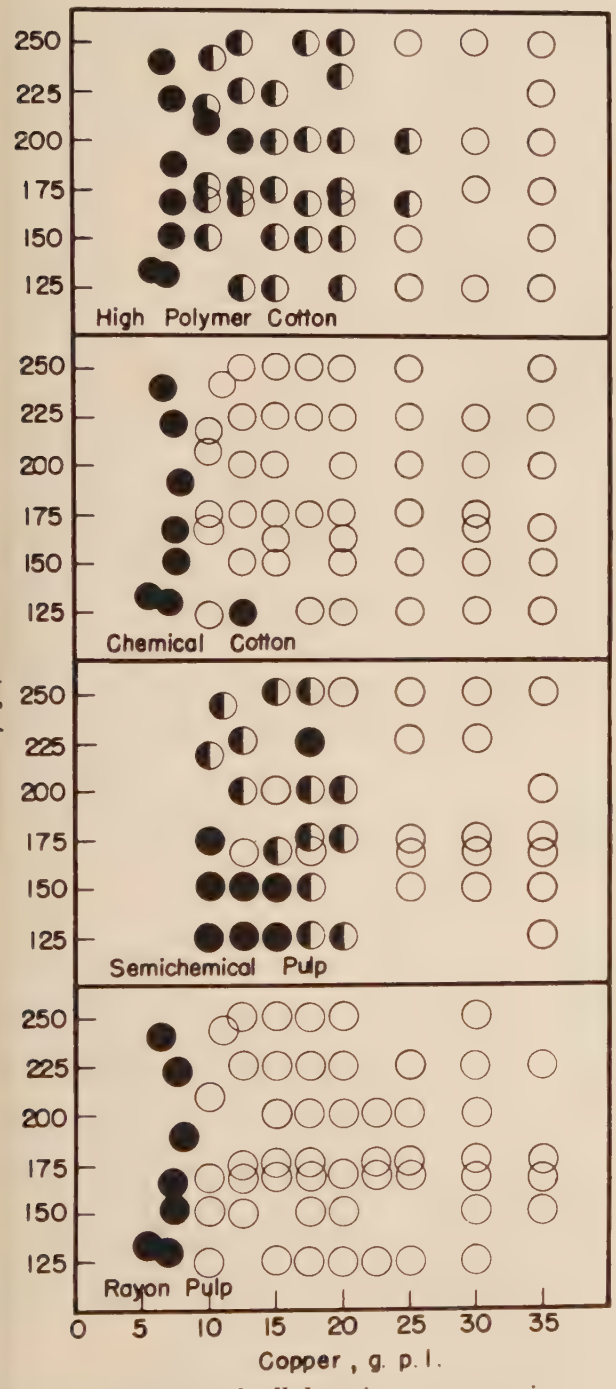

Fig. 4. Solubility of celluloses in cuprammonium

○ Soluble. ◐ Partly soluble. ● Insoluble.

The results of the solution tests in cupram are shown in Fig. 4. Each circle shows the result of one solubility test in a solution of the indicated copper and ammonia concentrations. Variations in ammonia concentrations over the range of 125 to 250 g.p.l. are without marked effect, and the dissolving power appears to be chiefly a function of the copper concentration.

The chemical cotton and rayon pulp are generally completely soluble in all solutions containing 10 g.p.l. or more of copper and containing ammonia in the range of 125 to 250 g.p.l. The high-polymer cotton proved very difficult to dissolve. Fairly complete solution occurred only in solutions containing 25, 30, and 35 g.p.l. of copper. Even in those solvents the resulting solutions were not microscopically clear, and some insoluble residues retaining approximately the shape of the original fibers were always present. The bleached semichemical pulp also was difficult to dissolve, and complete solution was obtained consistently only in solvents containing 25 g.p.l. or more of copper.

Stability and Dissolving Power of Cupriethylenediamine Solutions

The cuprien solutions were prepared from two master solutions which were prepared and analyzed according to TAPPI T 230 sm-50. The molar ratio of ethylenediamine to copper in these two solutions was between 1.85:1 and 2.00:1. From these master solutions, individual test solutions were prepared, in either 50 or 100-ml. lots, by the addition of calculated volumes of distilled water, and standardized ethylenediamine containing 200 g.p.l., to either a 50 or 100-ml. volumetric flask and filling up to the mark with cuprien from the stock bottles. As in the preparation of cupram solutions, the volumes of the three components used in making up the individual solutions were determined with the use of a simple chart from which the volumes of each component for each individual solution could be read directly.

The intrinsic viscosities of the cellulose samples were determined in cupram solution. The intrinsic viscosity in cuprien is stated to be 1.365 times that in cupram (*22*). Therefore, the oven-dry weight for each cellulose sample to be used in cuprien was determined by dividing the oven-dry weight used in cupram by 1.365, in order that the product of intrinsic viscosity and concentration equal 10 in this case as well. The same apparatus and procedures used for dissolving cellulose in the cupram solvents were applied for testing the cuprien solutions.

Figure 5 shows the results of the solubility tests. The compositions corresponding to base-copper molar

ratios of 2:1 and 3:1 are shown by diagonal lines designated 2 and 3, respectively. The area of best solubility occurs in the neighborhood of 30 g.p.l. of copper and 60 g.p.l. of ethylenediamine, which is approximately the 0.5 *M* copper solution used in TAPPI T 230 sm-50. At this concentration the chemical cotton and rayon pulp were completely soluble upon direct treatment with the solvent. The high-polymer cotton was only partially soluble, fiber residues being visible under magnification, although the amount of insoluble material was judged to be only slightly greater than with cupram. The use of a two-step dissolving procedure (addition of a diluted solvent, followed by the addition of the stronger solution according to TAPPI T 230 sm-50) did not noticeably improve the solution of the high-polymer cotton. The bleached semichemical pulp was only slightly soluble on direct treatment with solutions of the specified concentrations, but was completely soluble using the two-step procedure.

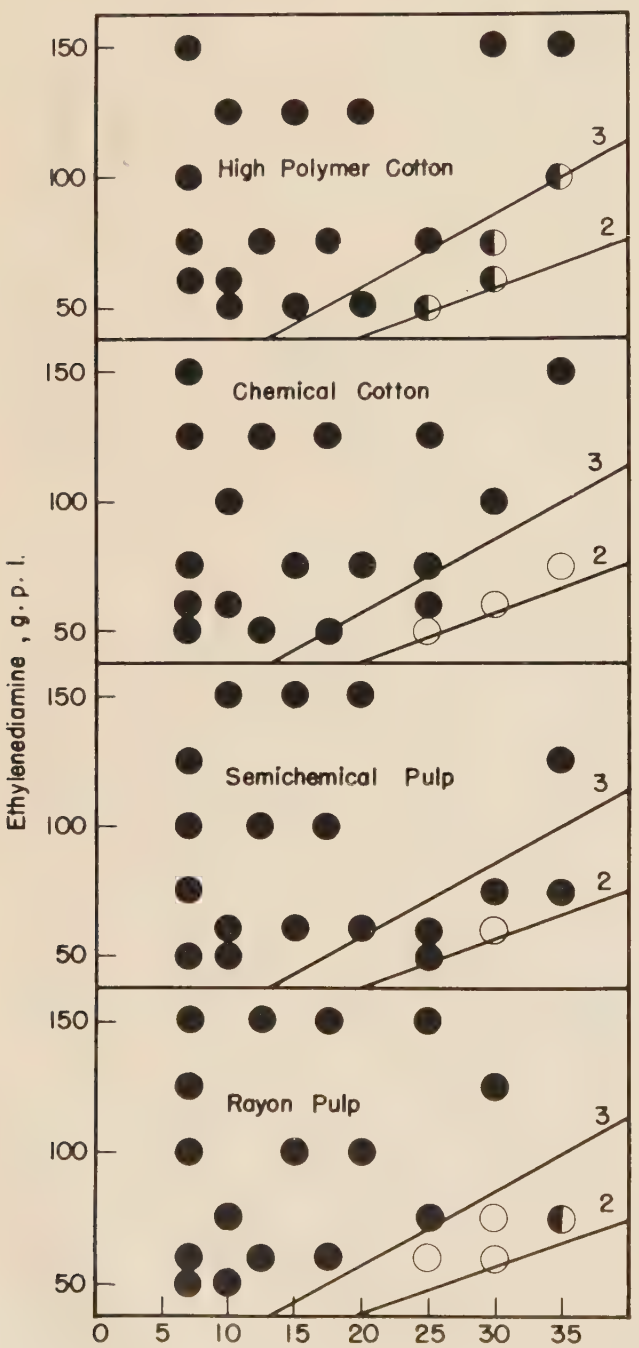

Fig. 5. Solubility of celluloses in cupriethylenediamine

○ Soluble. ◐ Partly soluble. ● Insoluble.

Two more solutions of a higher copper and ethylenediamine concentration were tested on the high-polymer cotton and bleached semichemical pulp samples using the direct-treatment method. The first contained 47.5 g.p.l. of copper and 89 g.p.l. of ethylenediamine, and the second contained 63.9 g.p.l. of copper and 119.3 g.p.l. of ethylenediamine. In each case the high-polymer cotton was partially soluble (fiber residues visible only under magnification), and the bleached semichemical pulp was only slightly soluble.

All solutions containing base in excess of an ethylenediamine-copper molar ratio of 3:1 failed to dissolve any of the cellulose samples tested. The solubility of copper hydroxide in the base limits the ratio to values above approximately 2. Thus, cupriethylenediamine solutions are effective cellulose solvents over only a restricted range of compositions.

The storage stability tests were carried out on 25-ml. portions of the solvents, which were stored for 30 days under nitrogen at 2 p.s.i. pressure and at a temperature of 23 °C., with the exclusion of light. No deterioration was observed in any of the solutions at the end of the 30-day test period.

The Specific Viscosity of Celluloses in Cuprammonium Solutions

The initial phase of the work served to delineate the general composition of cupram solutions which are unsatisfactory in character because of instability or inadequate dissolving power. There remained a more restricted "area" of compositions which it was desired to explore more throughly, and particularly with reference to the effect of copper and base compositions on the specific viscosity of the dissolved cellulose.

The specific viscosity is evaluated in preference to solution viscosity because of the desire to express the result in terms of intrinsic viscosity as suggested by Martin (*20*). The specific viscosity is calculated in this work in the usual manner:

$$\eta_{sp} = \eta_r - 1 = \frac{\eta}{\eta_0} - 1$$

where η is the viscosity of the cellulose solution and η_0 that of the solvent.

The study has been carried out in accordance with the suggestion of Martin (*20*) that the product of intrinsic viscosity and concentration be kept at a constant value. This procedure means that all celluloses are measured at the same solution viscosity and possess other advantages. Martin recommended that the product $[\eta]\ C = 5$, where C is the cellulose concentration in grams per deciliter. Additional study led Martin and co-workers (*21*) to suggest that the product $[\eta]\ C$ equal 3 might be preferable and this value was used in the present work.

The preliminary study indicated that optimum concentrations are about 15 to 30 g.p.l. of copper and 100 to 200 g.p.l. of ammonia. For determination of specific

Table I. Viscosity Data for Celluloses in Cuprammonium

	Solvents				Specific viscosity				
	Copper, g.p.l.	*Ammonia, g.p.l.*	*Specific gravity at 25°*	*Solvent viscosity, η_0, cp.*	*High polymer cotton, 0.1744 g./dl.*[b]	*Chemical cotton, 0.3260 g./dl.*[b]	*Rayon pulp, 0.4688 g./dl.*[b]	*Semichemical pulp, 0.5456 g./dl.*[b]	*Flax pulp, 0.3404 g./dl.*[b]
1	14.1	107	0.979	1.12	9.46	11.71	10.21	15.32	9.62
					9.62	11.76	10.28	15.54	9.50
2	15.1	149	0.965	1.18	7.74[a]	9.51	8.48	12.72	8.00
					8.25	9.56	8.64	12.42	7.96
3	24.8	98.1	0.999	1.15	10.08	12.06	10.46	15.00	9.57[a]
					10.02	12.04	10.51	15.16	10.02
4	22.9	152	0.976	1.22	...	10.04	8.34	...	9.71
						9.84	8.20	...	...
5	25.5	132	0.988	1.20	...	10.39	9.11	...	...
						10.40	9.23	...	...
6	25.3	152	0.980	1.24	7.94[a]	9.68	8.44	11.31	7.68
					7.89	9.60	8.21	11.64	7.79
7	25.4	176	0.970	1.27	...	8.68	7.68	...	...
						8.76	7.52	...	...
8	27.8	150	0.983	1.25	...	9.61	8.36	...	...
						9.76	8.46	...	...

[a] When these pulp solutions were examined under magnification an undissolved residue was visible.
[b] g./dl. = grams per deciliter.

viscosities, cupram solutions of the compositions given in Table I were prepared and analyzed for copper and ammonia contents according to TAPPI Standard T 206 m-44.

Solutions 1 and 2 were prepared by dissolving cupric hydroxide in ammonium hydroxide. The cupric hydroxide was prepared according to TAPPI Standard T 230 sm-50, except that washing by decantation was supplemented by filtration on a fritted glass Büchner funnel to obtain more complete removal of the liquid. The prepared cupric hydroxide was stored as a slurry in water. The excess water was sucked off on a fritted glass Büchner funnel and the paste of cupric hydroxide was added to the aqueous ammonia solution.

Solution 1 was prepared by adding an excess of cupric hydroxide to diluted ammonium hydroxide containing 10 g.p.l. of sucrose. The mixture was cooled in an ice bath to a temperature of 0 to −5°C. and stirred for 9 hr. at this temperature. The solution was filtered through glass wool and used without further adjustment. Solution 2 was prepared similarly but with concentrated ammonium hydroxide, and after 6 hr. stirring at 0 to −5°C. the resulting solution contained 18.7 g.p.l. of copper and 212 g.p.l. of ammonia. The composition given for solution 2 was achieved by dilution with water and by reduction of the ammonia content by applying suction from a water pump to the solution.

Solutions 3 through 8 were prepared from a single master solution by dilution with the required volumes of water and ammonium hydroxide. The solution contained 38.1 g.p.l. of copper and 200 g.p.l. of ammonia, and had a nitrite content of 1.61 g.p.l. It was prepared in a glass dissolving tube 4 in. in diameter and 60 in. deep and sealed off at the bottom. Copper turnings were packed into the tube to a depth of 40 in., and 8 liters of concentrated ammonium hydroxide were added. Air was bubbled through the tube for 5 hr. at the rate of 5 cu. ft. per hr. at room temperature.

The cupram solutions were adjusted to contain 10 g.p.l. of sucrose. After the initial preparation of the solution, the content of sucrose was determined and the required amount was added. The analysis for sucrose was carried out by boiling 25 ml. of the diluted cupram solution with 25 ml. of 0.2 *N* potassium dichromate solution and 40 ml. of concentrated sulphuric acid. After cooling the solution and diluting with water, the unreduced dichromate was titrated with 0.1 *N* ferrous ammonium sulphate solution using orthophenanthroline indicator. The method gave essentially complete recoveries of sucrose using the theoretical equivalent weight of 7.12. Under the same conditions of test, no dichromate was consumed by a cupram solution in the absence of sucrose.

The cellulose samples were stored in an air-dry condition in tightly stoppered bottles. The water content was determined on separate portions by drying at 105°C., and the required amount of sample to give the desired quantity of oven-dry cellulose was weighed out into the dissolving bottle for each test. Some glass beads were added to aid dispersion of the cellulose, and the pullover stopper was put into place. The bottle was alternately evacuated and flushed with oxygen-free nitrogen, and the desired quantity of cuprammonium solution was introduced from the buret attached to the apparatus. It was found convenient to weigh out a quantity of cellulose within the desired range, and to achieve the exact concentration of cellulose desired in solution by measuring out the calculated exact volume (approximately 25 ml.) of solvent from the buret.

The solution of the cellulose was generally complete at the end of 4 to 5 hr. shaking, because no increase in viscosity was observed when solutions were shaken longer, and a dissolving time of 5 hr. was used for all work involving cupram solutions. If complete solution did not occur within this time, the solution was still incomplete when dissolving periods were extended for several hours more. A number of the solutions prepared were examined microscopically and the occurrence of any undissolved material was noted.

Cannon and Fenske viscometers were used for all viscosity determinations. The size 200 viscometers were used for all determinations of specific viscosity. Size 50 viscometers were used for measuring the viscosity of solvents and size 100 for the dilute solutions needed for determining intrinsic viscosities. All viscometers were calibrated at 25°C. on standard oils from the National Bureau of Standards. Four size 200 viscometers were used in the work. The calibration constants ranged from 0.0806 to 0.0957.

All viscosity measurements were carried out at a

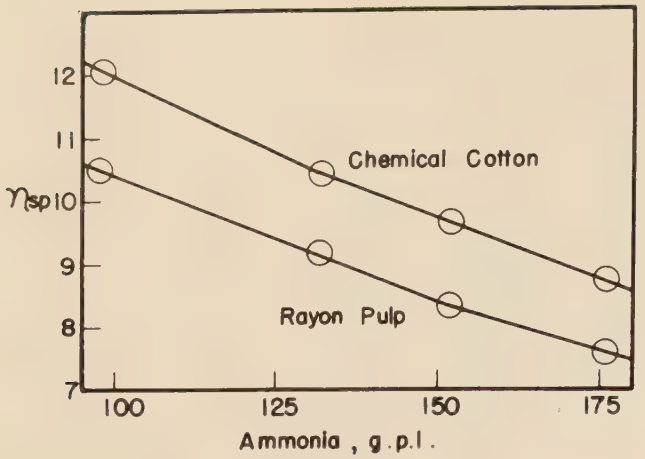

Fig. 6. Effect of ammonia concentration on specific viscosity (copper approximately 25 g.p.l.)

nominal temperature of 25°C. in a water bath (the actual temperature was 24.91 ± 0.01°C.). Specific gravity measurements on solutions were made in pycnometers after temperature adjustment of the solution in the water bath, and are given at 25°/25°.

To permit transfer of the cellulose solution to the viscometer in the absence of oxygen, a short length of gum rubber tubing was used to connect the two arms of the viscometer. The viscometer was alternately evacuated and filled with oxygen-free nitrogen through the needle which was inserted into the tubing. After the cellulose was dissolved in the serum bottle, the viscometer and bottle were immersed to suitable depth in the constant temperature bath at 25°C. for approximately 15 to 20 min. At the end of this time the correct volume of the cellulose solution was transferred from the dissolving bottle to the viscometer by a hypodermic syringe which had been previously flushed with nitrogen. The rubber tubing was removed from the viscometer and the flow time of the solution was determined. Flow times redetermined on the same solution were reproducible with 0.2 sec. or less.

The viscosity data are given in Table I. In general, variations in copper concentrations have little effect on the specific viscosity, whereas the ammonia concentration has a relatively large effect. These relationships are shown in Figs. 6 and 7 for chemical cotton and rayon pulp.

In order to obtain a quantitative evaluation, the specific viscosity data of Table I were calculated as a multiple regression on the copper and ammonia concentrations, using the method of least squares (*23*). It was assumed that the effects of ammonia and copper concentrations on specific viscosity are independent of each other and that the individual relationships are linear over the ranges studied.

The average specific viscosity for each pulp for each solution composition was used, and the resulting 28 equations of the following form were used to calculate the regression equation:

$$a + bx + cy = z$$

where x and y represent copper and ammonia concentrations, respectively, z is the specific viscosity, and a, b, and c are constants. The following equation resulted:

$$\eta_{sp} = 16.31 - 0.0204C - 0.0444A$$

where C and A are copper and ammonia concentrations, respectively, in grams per liter.

The constants of the regression equations were calculated individually for the chemical cotton and rayon pulp with the following results:

$$\eta_{sp} = 16.26 + 0.0036C - 0.0440A \text{ (chemical cotton)}$$
$$\eta_{sp} = 15.99 - 0.0086C - 0.0495A \text{ (rayon pulp)}$$

Too few data were available for the other celluloses to yield reliable constants for the individual equations. However, the relatively large effect of ammonia concentration and the much smaller effect of the copper content is consistent throughout.

These determinations have shown that cupram solutions having wide ranges of copper and ammonia concentrations are satisfactory cellulose solvents. It was noticed that solutions containing only about 100 g.p.l. of ammonia sometimes gave incomplete solution or required longer agitation. However, it is concluded from this work that cupram solutions over the very wide ranges of 125 to 175 g.p.l. of ammonia and 15 to 30 g.p.l. of copper are quite satisfactory cellulose solvents.

It will be noted that according to the Martin equation, the specific viscosity of all celluloses should be a constant if it is measured at a concentration such that the product of concentration and intrinsic viscosity is a constant (*20*). The data of Table I show quite appreciable differences in specific viscosity and in the a constants in the regression equations, particularly in the case of the semichemical pulp. One possible cause is the differing compositions of solutions used in determining intrinsic viscosities, a relationship which was not recognized at the beginning of the work. Other possible contributing factors may be the lack of control of velocity gradient in the determination of intrinsic viscosities, and the existence of some variability in the Martin slope constant for the celluloses. However, the purpose of the present work was primarily to compare specific viscosities for a given cellulose in solvents of different compositions at a given product of intrinsic viscosity and concentration; that is, for the one cellulose, at a constant cellulose concentration. For this reason, the deviation in specific viscosity between the various cellulose samples was not examined further.

The Specific Viscosity of Celluloses in Cupriethylenediamine Solutions

The qualitative experiments had shown that cuprien

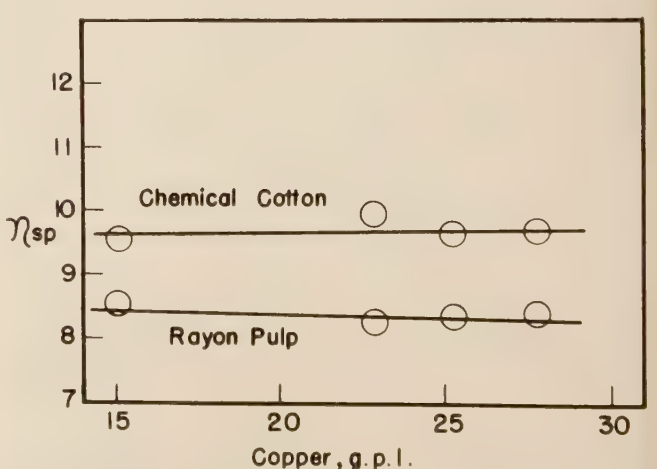

Fig. 7. Effect of copper concentration on specific viscosity (ammonia approximately 150 g.p.l.)

Table II. Viscosity Data for Celluloses in Cupriethylenediamine

	Solvents				Specific viscosity				
	Copper, M	*Ethylene-diamine, M*	*Specific gravity at 25°C.*	*Solvent viscosity, η_0, cp.*	*High-polymer cotton, 0.1744 g./dl.*	*Chemical cotton, 0.3260 g./dl.*	*Rayon pulp, 0.4688 g./dl.*	*Semichemical pulp, 0.5456 g./dl.*	*Flax pulp, 0.3404 g./dl.*
1	0.500	1.01	1.052	1.22	13.4	17.0	14.2	20.4	12.2
					13.0	17.4	14.4	22.4	12.0
					12.8	..	..	22.0[a]	
2	0.500	1.25	1.054	1.29	14.0	18.3	15.0	24.3[a]	13.2[a]
					14.0	18.0	15.1	23.1[a]	13.3[a]
3	0.750	1.51	1.076	1.45	12.1	15.9	13.3	20.1	11.7[a]
					12.4	15.6	13.5	20.7	11.3[a]
								19.9	
4	1.00	2.02	1.102	1.75	10.9	14.2	12.3	18.9[a]	10.5[a]
					11.1	14.2	12.4	18.3[a]	10.4[a]
5	1.00	2.50	1.102	2.00	11.1[a]	15.1	12.7	18.1[a]	10.7[a]
					10.9[a]	14.8[a]	12.6	18.5[a]	10.6[a]

[a] These celluloses were not completely dissolved as shown by microscopic observation.

olutions, only in the range of 0.5 *M* copper and with ase-copper ratios (*R*) between 2:1 and 3:1, were ufficiently good solvents to justify further study. Therefore, solutions in this area of composition were repared for specific viscosity tests. In addition to the olvents given in Table II, the following solutions were repared, but were found to dissolve the cellulose amples so incompletely that further study was unustified: Cu = 0.25 *M*, *R* = 2:1 and 3:1; Cu = 0.5 *M*, *R* = 3:1; Cu = 1.0 *M*, *R* = 3:1.

As in the study of cellulose solutions in cupram, the ests were run at concentrations of cellulose such that he product of intrinsic viscosity (determined in upram) and concentration equaled three. Because the urpose of the present work was primarily to study the ffect of base and copper concentrations on specific iscosity, the same concentration of a given cellulose as used in cuprien and in cupram solutions.

The general procedure of introducing sample and olvent into the dissolving bottles was the same as that escribed for the preparation of cellulose solutions in upram. However, the solution of celluloses by the irect addition of solvent to the cellulose, which was atisfactory with cupram solutions, gave poor results ecause of the formation of jellied lumps which did not issolve even upon prolonged agitation. Therefore, all iscosity data given for cuprien solutions were obtained sing a two-step dissolving procedure in which the ellulose samples were wetted with the amount of ater and ethylenediamine required to dilute the aster solution to the proper concentration with a final olume of 25 ml. A dispersion time of one hour was sed and it was determined that longer times did not gnificantly change the measured viscosities.

A master solution was prepared by adding an excess cupric hydroxide paste to a solution containing pproximately 200 g.p.l. of ethylenediamine and rotating the mixture overnight in a stoppered bottle. The solution was filtered through glass wool and analyzed for copper according to TAPPI T 230 sm-50. The use of Methyl Orange indicator in the titration for ethylenediamine as recommended in the TAPPI method did not give satisfactory results, and the titration was carried out potentiometrically with a glass electrode pH meter. The maximum inflection in the titration curve occurred at 2.75 pH, which is taken as the end point of the titration. The Methyl Orange end point is found at a considerably higher pH and corresponds to a much smaller acid titration. In the titration of ethylenediamine alone, the equivalent point from the potentiometric curve is at 4.2 pH, which is close to that given by Methyl Orange, and the slope of the titration curve is much greater at the equivalent point than in the titration of cuprien solution. The master solution was 1.58 *M* in copper and 3.18 *M* in ethylenediamine. This solution was used for all the tests by addition of the calculated volume to the required amounts of water and a standardized ethylenediamine solution as each test sample was dissolved.

The determined ratio of ethylenediamine to copper corresponds closely to the value of 2:1 reported by Straus and Levy (*16*), who confirmed the similar ratio found earlier by Traube (*15*). Jolley (*24*) found ratios of 1.78 to 1.89, and both he and McLean and Walker (*18*) pointed out that the ratio depends upon the actual base concentration. Both Straus and Levy (*16*) and Wilson (*25*) have recommended titration for ethylenediamine by a potentiometric method. Wilson found the end point at a pH of 3.05, and it appears that titration with the usual indicators may lead to considerable errors in the analysis for base.

The cuprien solutions and the viscosity data for the five celluloses are given in Table II. The percentage changes in specific viscosity occasioned by certain

Table III. Effect of Cupriethylenediamine Solutions on Specific Viscosity

	Change in η_{sp}, %				
Change in composition	*High-polymer cotton*	*Chemical cotton*	*Rayon pulp*	*Semichemical pulp*	*Flax pulp*
ffect of ethylenediamine					
0.5 *M* Cu *R* = 2 to *R* = 2.5	+7.0	+5.5	+5.2	+9.7	+9.5
1.0 *M* Cu *R* = 2 to *R* = 2.5	0	+5.3	+2.4	−1.6	+1.9
ffect of copper and ethylenediamine, *R* = 2					
0.5 *M* Cu to 0.75 *M* Cu	−6.3	−8.4	−6.3	−6.6	−5.0
0.5 *M* Cu to 1.00 *M* Cu	−15.9	−17.4	−13.6	−13.9	−13.6

R is the molar ratio of ethylenediamine to copper.

variations in composition are given in Table III. Increase in ethylenediamine at the 0.5 *M* copper level consistently increases the specific viscosity for all pulps. The effect at the 1.00 *M* copper level is less and is obscured by the poor solubility of some pulps in these solutions. If the base-copper ratio is maintained at 2.0, increase in copper concentration from 0.5 to 0.75 and to 1.00 *M* quite consistently and significantly increases the specific viscosity for all the celluloses.

Effect of Solvent on Intrinsic Viscosity

It has been established that the specific viscosity of a cellulose at a given cellulose concentration is markedly dependent on the composition of the solvent with respect to copper and base. The reduced viscosity (η_{sp}/c) follows the same relationship. Therefore, it is expected that extrapolated value of the reduced viscosity, the intrinsic viscosity, will also depend upon the composition used for the viscosity measurement. This has been found to be the case.

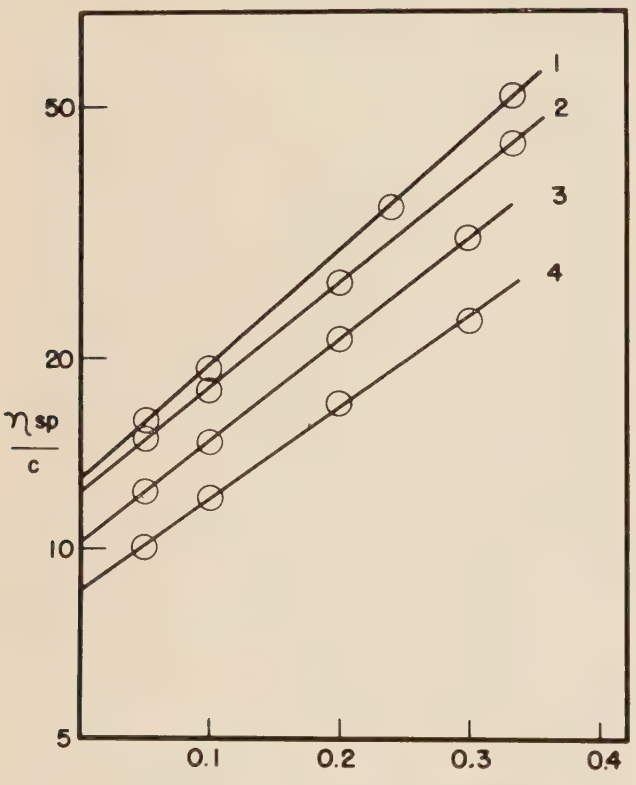

Fig. 8. The intrinsic viscosity of chemical cotton in four solvents

(1) 0.50 *M* copper, 1.01 *M* ethylenediamine. (2) 1.00 *M* copper, 2.02 *M* ethylenediamine. (3) 14.1 g.p.l. copper, 107 g.p.l. ammonia. (4) 25.4 g.p.l. copper, 176 g.p.l. ammonia.

Although it is generally recognized that the viscosity of the high polymeric materials is dependent upon the character of the solvent, it seems not to have been pointed out specifically that the intrinsic viscosity of cellulose in either cupram or cuprien solutions is a function of the copper and base concentrations of the solvent used in its measurement, and that differences as a result of solvent composition can be considerable.

The intrinsic viscosities of chemical cotton were determined with two cuprien solutions and two cupram solutions. The semilogarithmic plots are shown in Fig. 8. The intrinsic viscosities obtained by extrapolation are: in cuprien 0.5 *M* 12.8, 1.0 *M* copper 12.3; in cupram 14.1 g.p.l. copper 10.2, 25.4 g.p.l. copper 8.5.

These viscosity data were obtained at uncontrolled velocity gradients. Calculation of the mean velocity gradients (*26*) showed that they varied from about 150 to 2000 sec.$^{-1}$ Although the measured intrinsic viscosity is strongly influenced by velocity gradient during measurement (*22*), the effect is most important in the testing of higher molecular weight celluloses which may have intrinsic viscosities of 10 or more (*21*). In the work illustrated in Fig. 8, the comparisons shown must be relatively uninfluenced by velocity gradient because, for each solvent and each cellulose concentration, the viscometer constants and efflux times were nearly the same and, hence, the rate of shear did not vary by more than a few per cent.

It may be pointed out that the relationships given in Fig. 8 indicate that the intrinsic viscosities of celluloses in cupram and cuprien solvents can be brought closer together by a suitable choice of compositions. However, no compositions of the respective solvents which would give the same value for the intrinsic viscosity appear feasible.

The effects of solution composition on intrinsic viscosity may require consideration in studies of the intrinsic viscosity as a basic property of cellulose, and of values for the degree of polymerization which may be derived from the intrinsic viscosity by means of Kraemer's constant or of any other multiplying factor.

DISCUSSION

It was not the objective of the present work to recommend a procedure for a standard viscosity method, to establish definite copper and base concentrations, or to choose between ammonia and ethylenediamine as the base. However, some observations made during the progress of the work may be summarized at this point.

Both cupram and cuprien solutions are suitable solvents for celluloses, and in the necessary concentrations satisfactorily dissolve such difficult samples as high-polymer cotton, semichemical pulp, and bleached flax pulp. The permissible copper and base concentration ranges for these difficultly soluble materials are rather small. Nothing in this work has indicated any marked advantage of either cupram or cuprien on the basis of dissolving power toward a variety of celluloses or pulps.

Cupram solvents are effective over much wider ranges of copper and base concentrations than are cuprien solvents. This is not necessarily an advantage since, with either base, very reasonable plus or minus limits on concentrations are sufficient to maintain the solvent within an optimum range. The ammonia concentration in cupram solutions seems to have little effect on dissolving power over the range of 100 to 200 g.p.l. A copper concentration of 25 to 30 g.p.l. is required to completely dissolve the more difficultly soluble celluloses such as high-polymer cotton and semichemical pulp, although solutions of lower copper content (e.g., 15 g.p.l.) seem to be satisfactory in that undissolved residues do not appear to contribute significantly to the viscosity.

The change in specific viscosity with change in copper and base concentration is of about the same order for cupram and cuprien solvents. In cuprien solutions, the effect of copper content at constant base concentration can be studied over only limited ranges because of the limited solubility of cellulose when the base-copper ratio much exceeds 2:1. If the copper content is assumed to be without effect, the change in η_{sp} may be illustrated by the example of chemical cotton. In cupram, an increase of 75% (from 100 to 175 g.p.l.) in ammonia causes a decrease of 26.5% in η_{sp}. In cuprien, an increase of 100% (from 1.01 to 2.02 *M*) in ethylenediamine causes a decrease of 17.4% in η_{sp}.

The observations on stability of solvents confirm the general experience of other workers. Solutions containing about 10 g.p.l. of copper require addition of sucrose or other stabilizer. Even with sucrose present, many compositions of cupram solutions are less stable than cuprien solutions in the absence of air. That is, deposition of cupric oxide occurred during the one-month stability test as 23°C., whereas no deposition of cuprous oxide or other material occurred in cuprien solutions protected from air.

Both cupram and cuprien solutions can be prepared by solution of cupric hydroxide in the appropriate base. In the case of cupram solutions, the maximum copper content obtainable by this method is, according to our experience, in the range of 15 to 20 g.p.l. This is adequate for preparation of the TAPPI solvent, but it does not suffice for preparation of the ACS solvent, nor for preparation of a solvent to be used in a two-step dissolving procedure in which the final concentration is about that of the TAPPI solution. Cupram solutions above about 15 g.p.l. of copper must be prepared by the air oxidation method of Joyner, which leads to the presence of some nitrite in the solution.

Cellulose dissolves more quickly in cuprien (using the necessary two-step procedure) than in cupram with a one-step procedure, although any small fiber clumps which form a gel during the dissolving are dispersed very slowly. The solution of cellulose in cupram appears to proceed more slowly but more smoothly and without the occurrence of excessive gelling.

LITERATURE CITED

1. American Chemical Society, Division of Cellulose Chemistry, *Ind. Eng. Chem., Anal. Ed.* 1: 49–51 (1929).
2. Cross, C. F., Bevan, E. J., and Beadle, C., "Cellulose," London, Longmans, Green and Co., 1910.
3. Schweizer, E., *J. prakt. Chem.* 72: 109 (1857).
4. Worden, E. C., "Technology of Cellulose Esters," New York, Van Nostrand, 1921.
5. Ost, H., *Z. angew Chem.* 24: 1892–1896 (1911).
6. Gibson, W. H., Spencer, L., and McCall, R., *J. Chem. Soc.* 117: 479–493 (1920).
7. Joyner, R. I., *J. Chem. Soc.* 121: 1511–1525 (1922).
8. Farrow, F. D., and Neale, S. M., *J. Text. Inst.* 15: T157 (1924).
9. Clibbens, D. A., and Geake, A., *J. Text. Inst.* 19: T77–92 (1928).
10. Small, J. O., *Ind. Eng. Chem.* 17: 515–517 (1925).
11. Hahn, F. C., and Bradshaw, H., *Ind. Eng. Chem.* 18: 1259–1260 (1926).
12. Arkhipov, M. I., *J. Applied Chem.*, 21: 1107–1113 (1948); 22: 385–391 (1949); *C.A.* 43: 9435–9436.
13. Hisey, W. O., and Brandon, C. E., *Paper Trade J.* 120, No. 2: 43–52; No. 3: 41–44 (Jan. 11, 18, 1945).
14. Launer, H. F., and Wilson, W. K., *Anal. Chem.* 22: 455–458 (1950).
15. Traube, W., *Ber.* 44: 3319–3324 (1911).
16. Straus, F. L., and Levy, R. M., *Paper Trade J.* 114, No. 3: 31–34 (Jan. 15, 1942).
17. Hatch, R. S., *Ind. Eng. Chem., Anal. Ed.* 16: 104–107 (1944).
18. McLean, J. D., and Walker, F., *Tappi* 33, No. 2: 57–59 (Feb., 1950).
19. Almin, K. E., *Svensk Papperstidn.* 54, No. 18: 628–631 (Sept. 30, 1951).
20. Martin, A. F., *Tappi* 34, No. 8: 363–366 (Aug., 1951).
21. Wetzel, F. H., Elliott, J. H., and Martin, A. F., *Tappi* 36, No. 12: 564–571 (Dec., 1953).
22. Conrad, C. M., Tripp, V. W., and Mares, T., *J. Phys. Colloid Chem.* 55: 1474–1491 (1951).
23. Davies, O. L., "Statistical Methods in Research and Production," London, Oliver and Boyd, 1947.
24. Jolley, L. J., *J. Text. Inst.* 30: 122–141 (1939).
25. Wilson, K., *Svensk Papperstidn.* 55: 125–133 (1952).
26. Conrad, C. M., *Ind. Eng. Chem., Anal. Ed.* 13: 526 (1941).

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Selective Particle Separation by Controlled Fluid Forces on a Flat Screen

H. F. SCHENK

The construction and operation of flat screens to obtain maximum screening efficiency and dirt removal is given.

In order to control the fluid forces on a flat screen so that these forces are properly employed to secure the best results in selective particle separation, one must acquaint himself with the correctly dimensioned parts, construction, and arrangement of the unit. The process then becomes largely a separation of objectionable particles from good fiber by flotation rather than a mechanical sifting out of undesirable material. Many mills in the United States and Canada that have recently rebuilt or built new screen rooms now have the near full benefits of screening by the flotation method. They no longer depend on the minimum of slot sizes which are employed universally in Europe to mechanically sift out the wood dirt particles and large fiber bundles.

The new flat screens now available are not pressure-type screens although they employ air slightly in excess of atmospheric pressure as a blow back to keep the slots clean. This air blow back creates the flow pattern around the slots utilizing one half of the bar width on each side of the slots for this purpose (See "Controlled Hydraulics," *Tech. Assoc. Papers* 27: 375 (1944)).

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The creation of this flow pattern by the utilization of the air blow back has greatly increased the capacity of a five or six slot per inch screen plate over that of a plate cut seven, eight, nine, or ten slots per inch which depends upon either a water blow back or a hydrostatic head differential.

Pulp screened through moderate size slots, five or six to the inch, is not thrashed around excessively, scrubbed, beaten, or hydrated in the diaphragm chamber with this method, a very desirable feature inasmuch as the fiber is not broken or damaged by being pushed back and forth through the slots before joining the processed fiber in the stream of acceptable pulp.

The fibers pass through the air chamber in the diaphragm compartment into the pond of water, the depth of which has been regulated by the adjustment of the height of the dam controlling the priming seal. Fiber that passes into this area normally goes through the slot during the interval of one complete stroke due to the control of the length of stroke and the number of pulsations per minute allotted to moving the diaphragm. This fiber is neither roughed up, broken into smaller parts, nor hydrated. The objectionable speck material and fiber bundles can be floated off in the top of the stream flowing over the plates and reprocessed for further cleaning.

To place this objectionable speck material and fiber bundles in the top of the flow of pulp, a correctly designed headbox, apron board, flow approach control, and flock breaker must be provided at the head of the screen to properly arrange for the separation of good fiber from other material to be rejected. The dimensions of this headbox, apron board, and flock breaker have all been carefully worked out so that a laminar stream, evenly spread out over the screen plates at a controlled velocity is formed.

Between a flow created for a 28-plate line and a 14-plate line, it has been found that two 14-plate units, arranged in parallel, develop not only the highest capacity but also the cleanest pulp, in the relationship of approximately 50% more acceptable pulp with a corresponding decrease in speck inclusion. The highest capacity plates give the cleanest pulp; as the quantity diminishes through the succeeding plates in the second section of a 28-plate line the speck inclusion increases rapidly.

THE FLOW PATTERN

The initial flow pattern created on the bottom of the wetted area under the flow of pulp is greater in area over the first 14 plates than it is over the second 14 plates. For instance if it is 41 ± in. wide as it passes from the apron board to the first plate it becomes approximately 22 ± in. wide as it leaves the 14th plate—and because of the diminishing volume and velocity, the apex of this flow pattern cone is narrowed down to about 10 to 12 in. as it runs off the 28th plate; hence the very much lowered screening value of plates in a third and fourth plate section, if the line is that long. When a third and fourth plate section is used either stationary shower pipes or swinging pipe nozzles must be used to dislodge the pulp settling out in the stagnant areas adjoining the active part of the flow pattern or cone.

When the line is 48 to 56 plates long, selective particle separation by controlled fluid forces is the process in action on the head 24 or 28 plates which have normal size slots, while the last 24 or 28 plates must be composed of plates cut with the smallest of slots, because these must act as merely mechanical sieves.

Breaking Point Between Laminar and Turbulent Flow

The laminar flow breaks into a turbulent or rolling flow between 220 and 260 f.p.m.

An old hydraulic power plant axiom for controlling the flow through an earthen side-wall canal is to keep the flow at 3 f.p.s. to avoid the washing of the banks. This is a real example of laminar flow. By starting with a 180 ft. velocity, a flow over both units can be maintained that is well within the laminar flow range.

GOOD FLAT SCREEN PRACTICE

The headbox is a *must*—its purpose to create a laminar flow. The headbox is provided with a spreader baffle extending to the bottom of it and forming the first compartment. This baffle is about 2 ft. high. The incoming flow hits below the top to prevent channeling of the flow down over the screen.

Then follows a flow-head, height regulating baffle, placed so that the distance under it is slightly greater than the depth of the gradient to be used at the head of the screen. The baffle is located the same distance from the edge of the apron board as the depth of gradient at this point is expected to be. The pulp level behind this baffle is about 12 in. higher than the top of the flow gradient formed on the apron board.

A flock breaking water pipe placed in the bottom of the headbox and fitted with a center tee connection having $12^{3}/_{8}$ in. diam. holes, six on each side of the tee, is directed under the head-regulating-baffle and serves the same purpose in breaking up flocked fiber as the rectifier or holey rolls do in a headbox ahead of a fast running paper machine.

Flocked fiber does not form well on a paper machine wire, and flocked fiber does not screen well when it floats in bunches over the slotted screen plates. It dewaters to excess, further, the flocks of fiber tend to pull speck and shive material through the slots with them. To secure the cleanest pulp from flat screens flock breaking water showers and intermediate dilution well water pipes introduce the water into the under side of the main stream of pulp in the same direction as the flow of pulp.

Inlet and Flow Control Valves

It is generally considered good practice to provide a metering gate on the inlet pipe to control the volume of flow to the screen. A quick opening and closing gate valve for this purpose can quickly supply pulp or cut off the supply of pulp to the screen without disturbing the volume control. This is an inexpensive and efficient valve arrangement.

Controlling the Laminar Flow Velocity

To secure the top laminar foot flow per minute of 180 ft. ± at the first plate after the apron board, the whole unit is pitched or sloped $^{1}/_{8}$ in. per ft. starting at the edge of the apron board. The hydraulic jump which takes place at the 90° edge of the apron board

is called the area of centrifugal separation. The junction of the apron board and forward wall of the headbox forms a sharp right angle. Any streamlining of this edge subtracts from the centrifugal separating action occurring at this point.

The large dimensioned particles are tossed into the top of the flow, where they assume a flat, floating position and are kept in suspension by the flow forces generated from this point down over the screen plates. The efficiency and life of these fluid forces are limited. Top efficiency occurs over the first 14 plates, then rapidly drops off on the second 14-plate unit and ceases to function beyond that point.

Consistency

Consistency should not exceed 0.4% or fall below 0.25% for reasons of economy in processing the screened pulp as well as for efficiency of speck removal. All speck removal is relative; poorly cleaned or barked wood will show as dirty pulp regardless of how fine a slot is used or how short the screen lines are. If wood is cleaned with great care, the short flat screen is the most economical method of removing the small percentage of embedded wood dirt that is liberated from the pulp log by the chipper and the cooking process.

Operating Speed and Priming Seal Setting

Operating speed for the lift of the diaphragm should not exceed 580 strokes per min. at $^1/_8$ in. total lift. If the lift is greater, the number of strokes should be reduced. The dam setting for the control of the priming seals should start at the lowest possible position for the first two plates, and the remaining dams progressively raised up to that height required to produce a blow-back of low intensity through the slots in the last two plates on the line. Once a good operating setting of these dams is found, they should be permanently locked. The setting of these dams will be governed by the slot size and volume drainage through the plates. Under no circumstances should the height of any dam be set so that the water level in the diaphragm chamber reaches the under side of the screen plates. The resulting water hammer could cause severe damage to the equipment as well as serious injury to the fibers.

Flexibility of Operation Factors

Separate motors on each unit lend themselves to imparting great flexibility of operation, i.e., a 10-line job only cuts out one tenth of the production if one unit fails for a brief period. A huge, single pump and motor job as employed in some types of centrifugal cleaning, stops the whole operation if for some reason either the motor or pump needs attention. A stand-by pump or stand-by motor, both very expensive, are usually required in this case.

Consistency, volume, temperature, pH, and permanganate number control are all influential factors in maintaining sustained high capacity of high quality pulp. It might be added that plate life is extended also because the slots stay more uniformly open over a longer period, thereby keeping the strains on the plates at a minimum.

SOME CAUSES OF TROUBLE

Plate strains may result in peeled chrome-plated plates and cracked stainless plates, leaky plate fasteners, damaged diaphragms, and Pitman breakage. Summer temperatures tend to create greater frothing action when the pulp is agitated in the diaphragm chamber. The surfaces of these bubbles have a pitch or lignin coating which, when a bubble breaks against the under side of the plate, builds up an accumulation of this material, progressively plugging the slots, unless a special effort is made to keep the under side of the plates clean. Loss of capacity and plate damage may result. Fine slots lend themselves more readily to this plugging action. Clean plates have a tuning fork vibration or ring to them when sounded with one's finger nail across the bars.

Avoid Surges

In many cases prior to screening water is added to reduce the pulp to the desired consistency. A careful study of both the pumps and the mixing chamber should be made so that surges of light and heavy consistencies to the various screen units are avoided.

The kind of pumps used should not impart too violent a thrashing action so as to inflict any physical damage to the pulp. With the advent of the era of super high-speed paper machines the limited natural strength of cellulose fiber should be conserved to serve its purpose in forming a good strong sheet of paper at high speed. Good flat screen operation and maintenance can do this.

SCREEN ROOM CONSTRUCTION

If it is necessary to place a screen room in a building previously built which does not have proper dimensions for best screen arrangement, the screen lines should not exceed two 14-plate units with headbox, apron board, intermediate dilution well with short apron board, and run-off trough. The following dimensions are the recommended minimum:

2-ft. headbox
4-ft. apron board
15 ft. for the first 14-plate screen unit
3 ft. for the intermediate dilution well
2 ft. for the following apron board
15 ft. for the last 14-plate screen unit
2 ft. for the run-off trough
(12-plate screens which are 13 ft. long may be substituted with marked benefits)

The over-all length of the line built with 14-plate units is approximately 43 ft.; if built with 12-plate units, the length is 39 ft.

Experience has proved that 3 ft. is the best length for the intermediate dilution well to give maximum aid toward maintaining a laminar flow over the second unit. Shortening or lengthening this distance has proved to hinder rather than help screening efficiency in cases where it has been attempted.

The flock breaking water pipe and the intermediate dilution well are fed from the center and not from the ends, so that the pulp flow will be accelerated uniformly along each edge of the unit. This center feed in the intermediate dilution is located at the bottom of the well, on the upstream side with openings in the pipe pointed parallel with direction of flow. Feeding from the bottom center tee adds immensely to efficient operation by enlarging the effective part of the wetted flow cone over the plate surfaces immediately following the dilution well.

The efficiency of a flat screen 14 to 28 plates long, sloped 1/8 in. per ft. and fed a properly designed flow far exceeds that of a screen of greater length sloped 3/16, 1/4, 5/8, or 3/4 in. per ft. A screen sloped 1/8 in. per ft. develops a velocity of ±180 f.p.m., a 3/16-in. slope ±320, and a 1/4-in. slope ±420 f.p.m.

Collector Flumes or Pipes

If collector pipes are used to direct the acceptable pulp into a main line to the thickener, they are sharply pitched in the direction of the flow, but not perpendicular. By placing the collector pipes in a slanting position the tendency for the flow to vortex is greatly reduced, giving greater capacity of flow in the pipes. The pipes should be of adequate size to carry a maximum volume. The same should be said for the collector pipes used to carry the run-off pulp to the tailing or secondary screens. Poorly arranged pipes of inadequate dimensions vortex badly, impede the flow from the screen, and cause a back flood of pulp on the screen plates.

Foundations

Because a flat screen functions as a man-made earthquake, terrific vibrations, with their attendant harmonic waves, continually sweep through the building structure, the screen frames, and the screen plates—the screen room foundations should be well ballasted. At least three concrete foundations placed on an adequate footing for each 14-plate unit are recommended.

The above observations are the results based on successful application of approximately 40,000 stainless steel screen plates throughout the industry.

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Use of Jackson Church Press in Handling Pulp Mill Rejects

R. E. BRINGMAN

A brief résumé of St. Joe Paper Co.'s reject handling systems is presented, covering those previously employed along with the system presently used, which employs a Jackson Church Zenith press. Laboratory studies are outlined, illustrating the use of a Jackson Church type 015 high density refiner. These studies indicate the feasibility of using such a unit to refine the high density rejects without experiencing any degrading effect on the resulting liner board stock.

Handling of rejects has always been a problem facing mill operators. Each mill's operation is unique in itself with respect to the amount, size, and type of rejects separated from the acceptable fibers, due to the many, varied types and sizes of pulping equipment, cooking processes, and desired end products. So varied are the many means of handling rejects that evolutions within one particular organization occur over a period of several years' operation because of the process changes and quality of end product. St. Joe Paper Co. is no exception with regard to having a part in this evolution of reject handling. Some of the changes involved in the operation at Port St. Joe will be described briefly in this paper.

As all are aware, the rejects result from the separation of the acceptable fibers from the knots and uncooked portion of chips. In many instances these rejects contain considerable portions of acceptable fibers which cannot be made immediately available to the acceptable fiber storage. The disposal of these rejects, as previously stated, is accomplished through the use of wide and varied kinds of equipment incorporated into wide and varied disposal processes. Some of these disposal processes are: pressing and burning, ditching, refining in jordan-type refiners for subsequent use in low-grade fiberboard, dewatering and recooking, hammermill and disk-type refining for subsequent rescreening, and many, many others too numerous to enumerate at this time.

At St. Joe Paper Co. the first method of reject disposal, when it was still operating as a low-yield liner board mill, consisted of passing the rejects discharged from the tailing screens to a dewatering screen, discharging into a porgy press. In the porgy press the screenings were further dewatered and discharged to the chip belt where they were fed to the digesters for subsequent recooking. Figure 1 is a schematic diagram of the system used as described. Operational difficulties in the manipulation of the porgy press resulted in the discontinuance of the use of this system, and the rejects were fed directly from the dewatering screen to the chip conveyor belt.

When the cooking operation was modified to produce high-yield pulps, equipment for hot stock refining was installed ahead of the brown stock washing system and the reject disposal system was, therefore, revamped to allow the knots and slivers to be recirculated through the hot stock refining system. A schematic diagram of this reject handling system, used in conjunction with high-yield pulps, is illustrated in Fig. 2. In this particular instance, a dewatering screen received the rejects from the tailing screen and dewatered them to a consistency of from 5 to 8%. The dewatered stock then dropped into a dilution tank where it was mixed with first-stage black liquor and pumped to the blow tank to become a part of the blow tank dilution liquor. From the blow tank the rejects were recycled through the hot stock refiners and brown stock washing equipment for subsequent rescreening. Although this method was quite satisfactory from an ease of operation and maintenance standpoint, the amount of dilution water added to the black liquor in the blow tank, due to the low consistency of rejects fed from the dewatering screen, would amount to some 1,420,000 lb. per day of

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dilution water being added to the evaporator feed iquor. In an effort to eliminate a major portion of this dilution resulting from the water inherent in the rejects as received from the dewatering screen, it was decided to incorporate some type of press to raise the consistency of the rejects to such a value that would minimize the amount of dilution going to the blow tank. To this end the Jackson Church press was installed between the dewatering screen and the black liquor dilution tank. This press receives stock from the dewatering screen at a consistency of from 5 to 8% and discharges pressed reject stock at the bottom, having a consistency of 35 to 40%, depending upon the hydraulic pressure applied. For illustrative purposes, the following calculation was made: assuming an 8% inlet consistency and a 40% outlet consistency, and based on an estimated 5% rejects on 1200 tons of production, this amounts to decreasing the dilution water from 1,420,000 to 180,000 lb., or a net decrease of 1,240,000 lb. per day. At a steam economy of 4.0 lb. of water per pound of steam at the evaporators, and a 50¢ steam cost, a savings of $155 per day in evaporator steam costs is realized.

The press is so situated that its discharge falls freely into the dilution tank which is equipped with an agitator and the necessary supply and pump-out lines for delivery of the black liquor and reject slurry to the blow

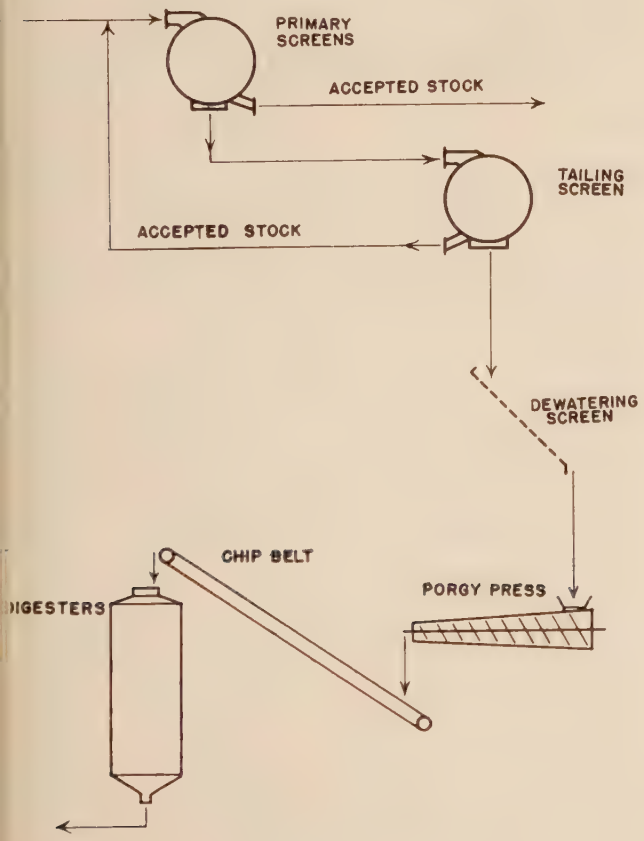

Fig. 1. Former knot disposal system

tank. A schematic diagram of this system is shown in Fig. 3.

When the expansion program is completed, there will be two Jackson Church type 010 Z-L pulp presses, each capable of dewatering 35 tons of kraft rejects from a consistency of 5 to 8% to a final consistency of from 35 to 40%. These Zenith continuous presses consist essentially of a heavy, tapered screw-type spindle, integral with which are arranged ingeniously constructed flights. This spindle rotates at a relatively low speed of

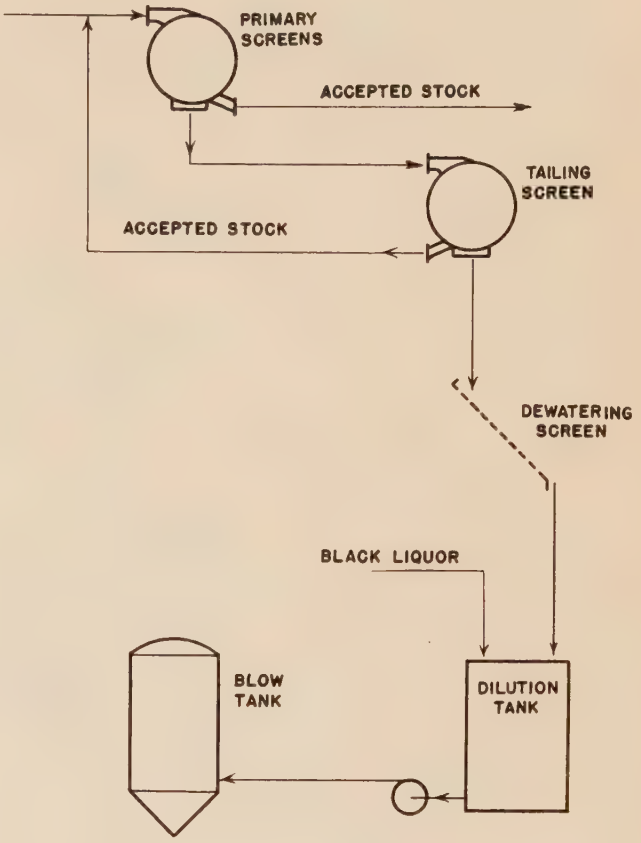

Fig. 2. Former knot disposal system

approximately 5 r.p.m. inside a close-fitting, heavily reinforced cylindrical outer screen of type 316 stainless steel, 11 gage having $^{3}/_{16}$-in. drain holes. This heavy cylindrical outer screen is lined with a 24-gage type 316 stainless steel liner screen having 0.040-in. drain holes. Sixteen resistors project through this screen and act to retard the pulp, causing a continuous action of the flights on the pulp, forcing it downward through the increasingly restricted opening between the body of the spindle and the outer screen. During the downward movement of the rejects the slurry is constantly rolled over and the water is squeezed out through the screen perforations. When the concentrated rejects leave the last flight at the bottom of the spindle, they are still under pressure and are forced through a second restricted, tapered opening which in this case is variable as to the port size and where it received additional pressure. This second pressure zone has upper and lower drainage screens constructed of type 316, 16-gage stainless steel screen plates, having $^{3}/_{16}$-in. drain holes on $^{1}/_{16}$-in. centers, with a liner screen of 24-gage, type 316 stainless steel. The liner screens contain 0.040-in. drain holes on 0.075–in. staggered centers which permit the escape of the remaining removable water before the reject cake is ejected. This feature prevents the reabsorption of the already removed water and assures

maximum separation. Total drainage area for this particular press is over 55 sq. ft. The previously mentioned resistors, of which there are 16 in banks of four, project through the outer screen and into the body of the reject slurry, and tend to prevent the pulp from turning

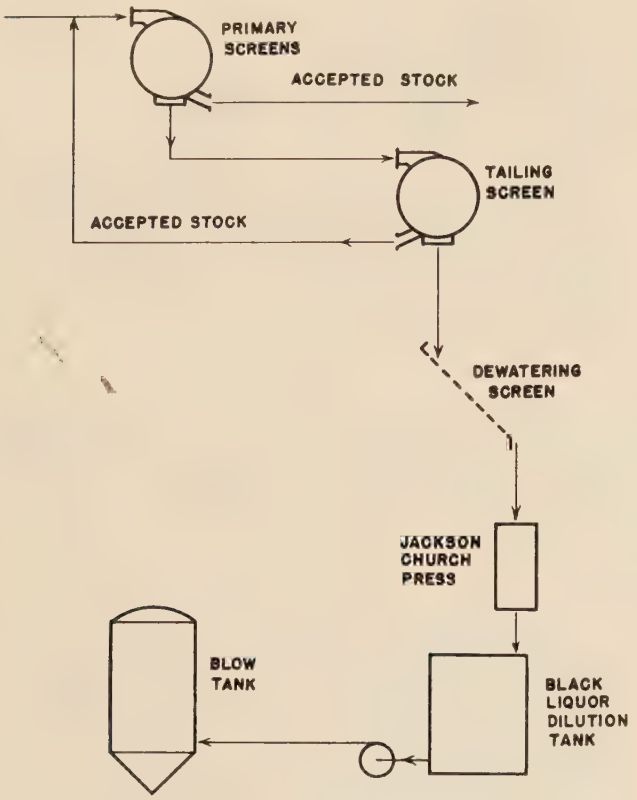

Fig. 3. Present knot disposal system

with the spindle and causing it to roll over under pressure, thus effecting greater liquor removal. These resistors are rifle drilled to facilitate steam injection which tends to warm the reject slurry and increase the draining efficiency.

LABORATORY STUDIES

There has been considerable thought given to the possibility of refining the rejects as discharged from the Zenith press in some type of a high density refiner which would therefore eliminate the necessity of rediluting the already dewatered rejects with black liquor and passing them once more through the low-consistency, high-liquor torque refiners and subsequently on to the brown stock washing and screening systems. It was thought that considerable power savings could be realized through the use of high-density refiners, coupled with the saving resulting from complete elimination of black liquor dilution and the increased capacity effected through the elimination of recycling of the rejects through the refiners and over the brown stock washing system. In view of these seemingly possible savings, laboratory studies were made to determine whether or not the rejects as discharged from our tailing screens and dewatered in a Jackson Church press could be refined in a high-density refiner and returned to the accepted stock system for subsequent usage in liner board stock. A suitable portion of rejects, as discharged from the Jackson Church press in operation at the St. Joe plant, was sent to Saginaw, Mich., and refined in a Jackson Church type 015 high-density refiner. These pressed rejects were given two degrees of refining; one sample being refined by having one pass through the high-density refiner, while the other sample was processed by allowing the rejects to be given another degree of refining through the same high-density refiner. It is of significance to note at this time that, should it be found advisable to process the screenings in the above manner, no large slivers would be able to reach the machine chest as the refiner discharge would be so arranged as to send the refined rejects to the unscreened stock chest and consequently subject them to a rescreening process. As an experimental pulp screen was not available at the time of this laboratory investigation, this rescreening process could not be simulated in this particular experimentation. Beater runs were made on five different stock combinations. As 3 to 5% rejects are presently produced the final two beater runs contain stock consisting of 5% refined rejects and 95% mill stock so as to simulate mill operation as closely as possible. These five beater runs will be designated for clarity purposes in this report as follows:

Run No. 1: Rejects, one pass through refiner, Fig. 4
Run No. 2: Rejects, two passes through refiner, Fig. 5
Run No. 3: Deckered stock from the screens, Fig. 6
Run No. 4: 95% screened stock plus 5% single pass rejects, Fig. 7
Run No. 5: 95% screened stock, plus 5% double pass rejects, Fig. 8

The results of these five beater runs are shown in the

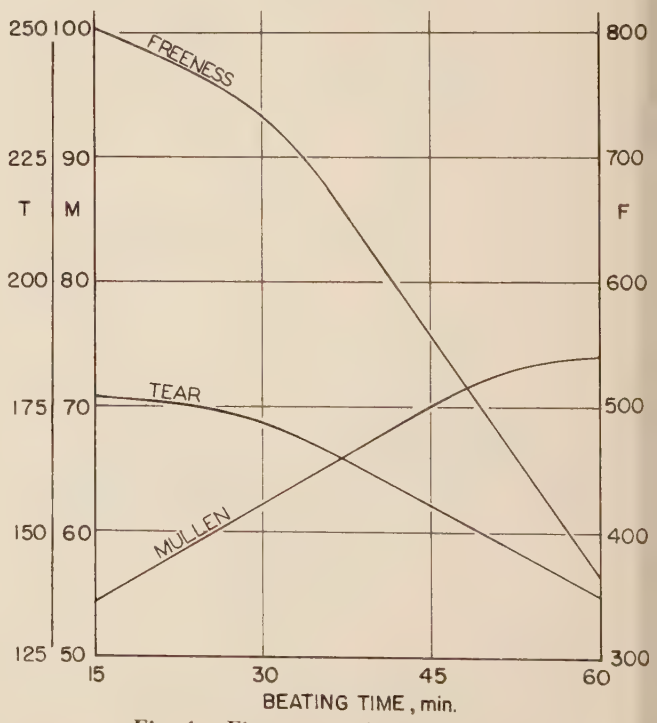

Fig. 4. First pass rejects, 11/19/51

figures. Pulp values were calculated from the graphs by totaling the 30 and 45-min. bursting strength values and doubling the sum. Added to this calculated burst value is the sum of the 30 and 45-min. tear. The combined burst and tear values result in a pulp value which

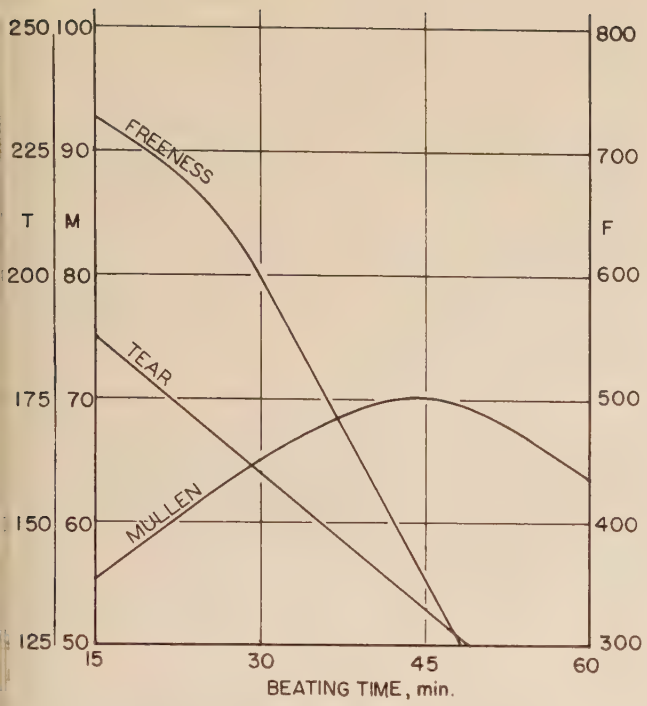

Fig. 5. Second pass rejects, 11/23/51

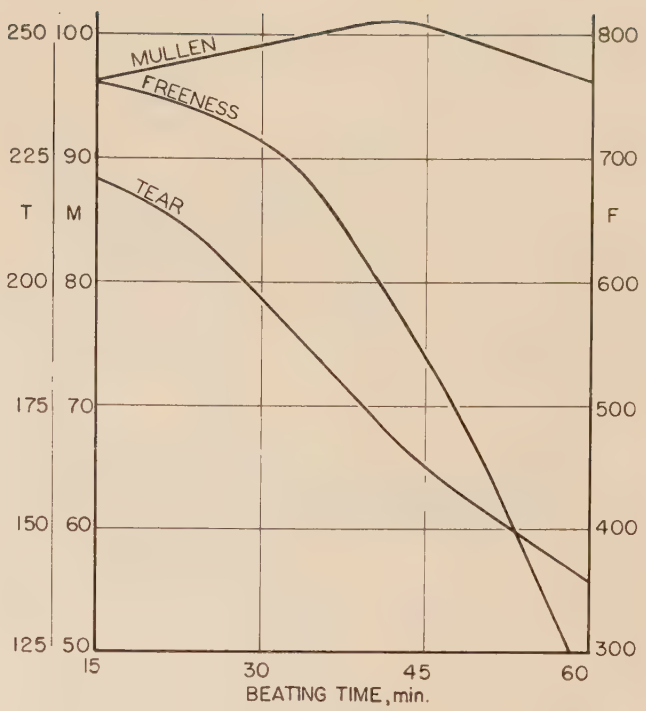

Fig. 7. Fourth stage stock +5% first pass rejects

s an arbitrary number used by the laboratory staff to determine pulp quality. All tear and burst values were corrected to a 26 lb. per thousand square foot basis. The pulp values determined for the five different runs, as outlined above, were as follows:

Run No. 1: Pulp value 591
Run No. 2: Pulp value 564
Run No. 3: Pulp value 710
Run No. 4: Pulp value 763
Run No. 5: Pulp value 749

From the above pulp values and the figures it is apparent that the 5% refined rejects in the stock had no degrading effect on the finished product. Further, no appreciable increase in pulp values was realized by giving the rejects another degree of refining.

As previously stated, the experimentation outlined above was conducted in an effort to determine the feasibility of such an operation in conjunction with the reject handling system and has not, at the present time, progressed sufficiently to warrant full-scale conversion to its use on a total mill operation basis.

Laboratory investigations described have borne out the feasibility of passing high-consistency rejects directly into a high-density refiner without first rediluting with black liquor and passing them through conventional refiners thereby reducing the power load and in-

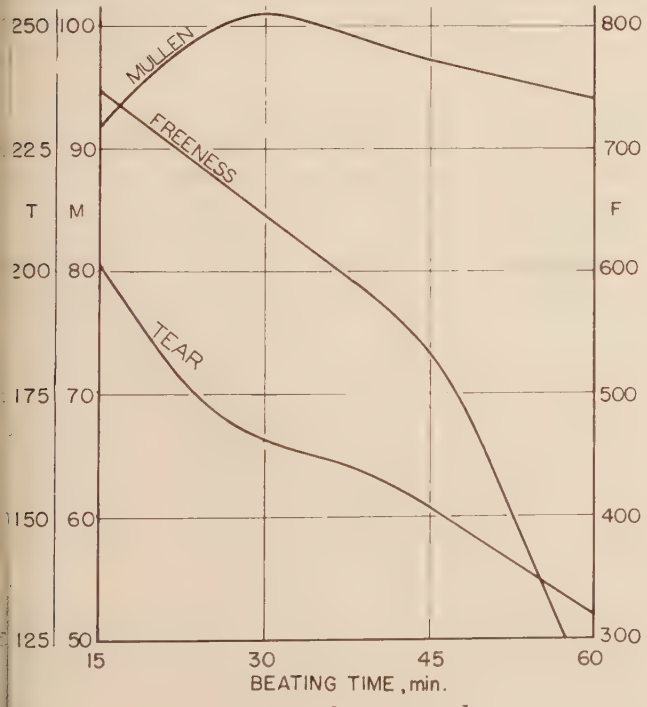

Fig. 6. Fourth stage stock

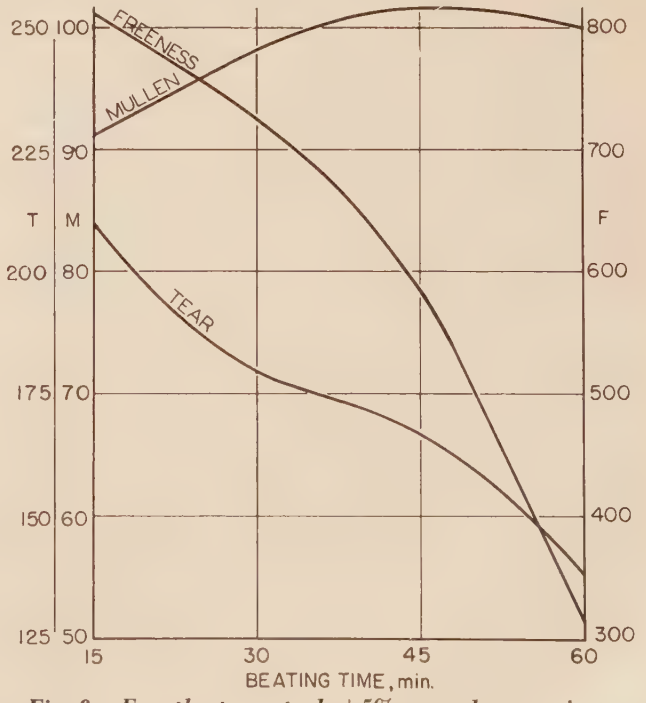

Fig. 8. Fourth stage stock +5% second pass rejects

creasing the capacity of the refining and brown stock washing system.

SUMMARY

The evolution of reject handling systems at St. Joe Paper Co. is twofold. First, efforts are constantly being made in the industry to improve process methods to insure ease of operation and good economy. As a consequence, St. Joe Paper Co. followed very closely the development of process equipment that would yield high-density rejects to their refining system thereby reducing the amount of dilution water fed to the blow tank which must eventually be evaporated at the vacuum evaporators. Second, with the incorporation of high-yield hot stock refining into the pulping process, the need for a different method of handling rejects was apparent. Through the use of a Jackson Church press it was possible to send 35 to 40% consistency rejects to the blow tank for subsequent recycling through the hot stock refining system.

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Measurement of Retention of Locust Bean Gum by Analysis of Sugar Units

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A new analytical method has been developed for the determination of the locust bean gum content of paper. This new method possesses the advantage that it can be used for testing prepared paper samples and, therefore, measures the true gum content of the paper. The steps involved are hydrolysis with dilute sulphurous acid, recovery of sugars, separation of the sugars by paper partition chromatography, and determination of the sugars by oxidation with sodium periodate. Although particular conditions have been chosen in this work, the method is adaptable to a variety of applications.

A number of years ago Hunter (*1*) revealed that *Hibiscus manihot* was used by the Japanese to obtain improved formation with long-fibered pulps. Since that time a wide interest has been awakened in the field of beater additives or beater adhesives. Particularly notable are the studies of Broadbent and Harrison (*2*), who found that *Hibiscus manihot* and deacetylated karaya gum were excellent deflocculents, and of Swanson (*3*), who found that guar and locust bean gum were particularly effective in bringing about strength increases in paper. It was quite natural, therefore, that means would be sought for the determination of the retention of beater additives. The only fundamental study made on the determination of the retention of these additives has been reported by Shriver, Webb, and Swanson (*4*). One procedure makes use of the color reaction between anthrone in sulphuric acid solution and the polysaccharide. The second technique is a viscometric method. In both methods, the analysis is applied to a filtrate from a pulp-beater additive-water slurry. Both methods are quite rapid and suitable as routine analytical tools. The criticisms which have been made of these methods are that they are indirect, they are not specific for the beater additive, and inaccuracies are aggravated in the case of beaten pulps. In addition, of course, they are not suitable for analysis of paper samples. The need for a new method which would be applicable to prepared paper samples and would overcome the objections to the currently available methods prompted the present investigation.

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THEORY

Locust bean gum and pulp are composed ultimately of simple sugar units. The predominant simple sugar unit in pulp is glucose, but others, such as mannose, xylose, arabinose, and galactose may also be present; locust bean gum is composed solely of mannose and galactose units (*5*). When the contents of mannose or galactose of both the pulp and locust bean gum are known, the proportion of locust bean gum present in a pulp sample of known weight can be determined by analysis of the mannose or galactose content of the sample.

Although the theory for the proposed new method is simple, there were a number of important considerations which had to be studied before a practical method could be evolved.

The amount of locust bean gum ordinarily present in pulp or paper samples is quite low—probably less than 3%. It was seen that only small quantities of simple sugars could be recovered from the locust bean gum present in a pulp sample. Thus, it was important that the sugar unit chosen for analysis (mannose or galactose) be present in locust bean gum in an appreciable amount; on the other hand, the pulp had to contain very small amounts or none at all of the chosen sugar.

In order to recover the simple sugars for analysis, it was essential that all the locust bean gum be dissolved and removed from the pulp residue by a hydrolytic treatment. Obviously, the method would not be quantitative unless complete removal of locust bean gum were accomplished. In addition, it was also necessary that the hydrolytic technique bring about complete hydrolysis of the locust bean gum.

It was also important that there should be no destruction of sugars during the hydrolysis or during the later steps necessary in the analysis. Finally it was desirable that the time required for analysis of the samples be kept to a minimum.

STUDY OF THE SUGAR UNITS PRESENT IN THE PULP AND LOCUST BEAN GUM

The pulp selected for this work was a western bleached sulphite pulp and the beater additive used was locust bean gum. The pulp was hydrolyzed by two methods to determine the component sugars. Complete hydrolysis with 72% sulphuric acid was carried out and the recovered sugars were subjected to chromatography on a clay column (*6*) using 95% ethanol as the developer. Appropriate cuts were made of the effluent and the extruded column was sectioned and eluted. Each fraction was spotted on filter paper and subjected to paper partition chromatography using a pyridine-butanol-water (3:10:3) solvent system. The chromatograms revealed large quantities of glucose in most fractions and smaller but quite appreciable amounts of xylose and mannose in several fractions. Only one fraction contained galactose and the amount was very minute. The experiment was qualitative in nature, but it was easily seen that the amount of galactose present in the pulp was less than 1%. On the other hand, mannose was present in much larger amounts. It should also be noted that no rhamnose was found in the pulp.

The second hydrolytic method used was a treatment with sulphurous acid. Samples of the pulp were hydrolyzed with 3 to 5% sulphurous acid in a sealed Pyrex tube for 80 min. at 135°C. according to a method developed by Dickey (*7*). The sugars were recovered as described later and were subjected to paper partition chromatography. Only a very weak spot was obtained for galactose, whereas mannose was present in an appreciable quantity. Again, no trace of rhamnose was found.

Locust bean gum was also hydrolyzed with sulphurous acid. Paper partition chromatograms showed that both mannose and galactose were obtained from the gum in appreciable quantities, but that no other sugars were present. At this point it was apparent that this method for the determination of locust bean gum content of paper should be based upon the galactose present in the system.

Table I. Galactose Content of Locust Bean Gum

Sample	*Gum, g.*	*Galactose, g.*	*Galactose from gum, %*
1	0.0476	0.00911	18.6
2	0.0970	0.01375	13.8
3	0.1440	0.02070	13.9
4	0.1254	0.02235	17.2
5	0.0741	0.01529	20.0
6	0.1511	0.02705	17.4
7	0.0800	0.01390	16.9
8	0.0690	0.01100	15.5
9	0.1113	0.01950	17.0
10	0.1194	0.01289	10.5
11	0.0967	0.01390	13.9
12	0.1164	0.01436	11.9
13	0.1609	0.02910	17.5
14	0.1015	0.01620	15.5
15	0.0902	0.01636	17.6
Average			15.7

Quantitative determinations of the galactose obtained from pulp and from locust bean gum by sulphurous acid hydrolysis were next carried out. The sugars were determined by oxidation with sodium periodate as described by Flood, Hirst, and Jones (*8*). Tables I and II show the galactose content of the gum and of the pulp. This average value was slightly lower than others reported in the literature, i.e., 16.5% (*9*), 16.5, 17.5, and 18.5% (*10*), and 20% (*11*). Recently Hirst and Jones (*12*) have reported values of 14.0 and 16.0%.

Table II. Galactose Content of Pulp

Sample	*Pulp, g.*	*Galactose, g.*	*Galactose from pulp, %*
1	1.179	0.000096	0.0078
2	1.474	0.000241	0.0164
3	1.315	0.000143	0.0109
4	1.236	0.000193	0.0156
5	1.291	0.000177	0.0137
6	1.372	0.000206	0.0151
7	1.308	0.000143	0.0109
Average			0.0129

These quantitative data demonstrated that galactose should be the sugar unit determined for this method. It was apparent that the amount of galactose removed from the pulp was sufficiently low so that only small control or blank values were required.

REMOVAL OF LOCUST BEAN GUM FROM PULP BY HYDROLYSIS WITH SULPHUROUS ACID

Samples of untreated pulp and of pulp treated with locust bean gum were prepared using a moderately beaten pulp. One specimen of each was subjected to sulphurous acid hydrolysis, the pulp residues were recovered and dried, and the hydrolyzates were subjected to paper partition chromatography. The pulp residues as well as specimens of the original samples, were hydrolyzed with 72% sulphuric acid, as described previously, and the sugars were recovered and concentrated *in vacuo*. The sugars were then separated on a clay column using 95% ethanol as a developer and the various effluent cuts were spotted for paper partition chromatograms. The chromatograms were developed in the pyridine-butanol-water tank for 48 hr. The following evidence was obtained from a study of the paper partition chromatograms.

1. The sulphurous acid hydrolyzate of the pulp sample gave a very weak spot for galactose; the hydrolyzate of the pulp containing locust bean gum gave a strong spot for galactose.

2. No galactose was found in any of the fractions obtained from the sulphuric acid hydrolyzates of pulp residues which remained after hydrolysis with sulphurous acid.

3. The sample of the original pulp containing gum which was hydrolyzed with sulphuric acid showed a large spot for galactose from one fraction and a lighter spot from another fraction. The sample from the untreated pulp gave only a weak spot for galactose from one fraction and a questionable spot from another fraction.

These results demonstrated conclusively that sulphurous acid hydrolysis accomplished quantitative removal of the locust bean gum from the pulp.

Hydrolysis of locust bean gum samples for determination of galactose content was carried out with sulphurous acid (see Table I). The chromatograms of the hydrolyzates showed clearly that the only sugars present were mannose and galactose. No material was held at the upper part of the chromatogram (above the galactose band) as would be the case if incomplete hydrolysis were encountered.

It should be emphasized that, although sulphurous

acid produced rapid, complete hydrolysis of the gum, only a small amount of the pulp was hydrolyzed. For example, this method yielded 4 to 8% of the pulp sample as simple sugars. A small portion of the glucose was removed, together with most of the other sugars present in the pulp. Using this method, the major portion of the glucose was not hydrolyzed, so that paper partition chromatography could be applied directly to the hydrolyzates. It should also be mentioned that the pyridine-butanol-water (3:10:3) solvent system used for the paper partition chromatography afforded good separation of glucose and galactose—a difficult pair of sugars to separate (*13*). This laid additional emphasis on the desirability of minimizing the attack on the pulp during hydrolysis of the gum.

POSSIBLE DESTRUCTION OF GALACTOSE

The only likely steps during which destruction of galactose would occur were the hydrolysis and recovery of sugars. Samples of galactose were subjected to the hydrolytic treatment and the amount of sugar which was recovered was determined gravimetrically. Recovery was complete within 2% in all cases. It was obvious that no appreciable loss of material had occurred. It was suggested that barium carbonate, if used in excess in the recovery of the sugars, might make the sugar solution sufficiently alkaline to cause epimerization. Epimerization of D-galactose would produce D-talose and, possibly, the ketose, D-tagatose. Samples of galactose were subjected to the recovery-of-sugars step in the presence of barium carbonate. The samples were concentrated and spotted on chromatograms along with appropriate reference sugars. After development and spraying, the chromatograms indicated that a limited amount of epimerization was encountered. Similar results were obtained for galactose which had been subjected to the hydrolytic and recovery steps. Quantitative determination showed that the loss of galactose in the presence of barium carbonate amounted to 3.5%. In some cases, it appeared that even less epimerization occurred. Although the loss of galactose by epimerization was measurable, it will later be shown that the extent of epimerization encountered is not significant when compared with the accuracy of the method as a whole.

REPRODUCIBILITY OF METHOD

Two sets of samples were prepared for the study of the reproducibility of results. Both sets were made from a single pulp suspension treated with approximately 5% locust bean gum. The pulp had been beaten for 40 min. in a laboratory Valley beater with a bedplate loading of 5500 grams.

The first set of samples (A) was formed into 2-gram sheets on a British sheet mold using the normal procedure. The second set (B) was formed on an 80-mm. Büchner funnel equipped with a wire mesh, and the filtrate from the first pass was recirculated in order to retain the fines in the pad. Two-gram sheets were again prepared.

The sheets in each set were cut into small squares and samples were drawn at random. The samples were analyzed according to the procedure described below. Table III shows the analyses for gum content of the various samples.

The galactose method clearly distinguished between the two groups of samples whose locust bean gum contents differed by only 0.37%. According to statistical theory (Student's t test), it is practically impossible that the A samples had the same gum content as the B samples.

Table III. Reproducibility of Galactose Method

Sample	*Weight, g.*	*Galactose, g.*	*Gum, g.*	*Gum, %*
A-1	1.646	0.00290	0.01848	1.12
A-2	1.614	0.00281	0.01790	1.11
A-3	1.737	0.00326	0.02072	1.19
A-4	1.617	0.00296	0.01888	1.17
A-5	1.663	0.00345	0.02200	1.32
Average				1.18
High				1.32
Low				1.11
B-1	1.803	0.00410	0.02612	1.45
B-2	1.952	0.00549	0.03495	1.79
B-3	1.794	0.00407	0.02590	1.44
B-4	1.922	0.00428	0.02725	1.42
B-5	1.741	0.00413	0.02630	1.51
B-6	1.646	0.00443	0.02822	1.71
Average				1.55
High				1.79
Low				1.42

It is particularly interesting that these two sets of samples have different gum contents, but not at all surprising. One would expect the fine cellulosic material to have a greater adsorptive surface than the long-fibered material. Therefore, the samples prepared with recirculation of the filtrate should have a higher gum content (as was the case). It is also to be pointed out that these two sets of pulp samples were prepared from a common pulp-gum slurry. The new method using the paper samples has been able to differentiate clearly between the two samples, whereas, they would have been considered as identical in gum contents if analyzed by the anthrone or by the viscometric methods which use the pulp slurry for samples.

DESCRIPTION OF METHOD IN FINAL FORM

The steps involved in the procedure may be outlined as given below: (1) preparation, sampling, and hydrolysis; (2) recovery of sugars; (3) separation of sugars; and (4) determination of sugars.

Preparation, Sampling, and Hydrolysis

The preparation of samples will not ordinarily be required because the method will be used to determine the locust bean gum content of prepared papers. In much of the preceding work a wire mesh was used to prepare sample sheets so that the normal sheetmaking procedure would be imitated.

Any method of sampling which supplies random representative samples will be satisfactory. Where two or more specimens of the same sample are used, it is considered good practice to cut the paper sample into small squares and draw each specimen at random.

Each sample may be individually oven dried at 105°C. or a separate moisture sample may be taken. Approximately 2 grams of oven-dry material are weighed on an analytical balance to the nearest milligram. The sample is transferred to a reaction tube of 16-mm. Pyrex glass tubing which has been sealed at one end. The contents of the tube are well covered with a solution of sulphurous acid made by diluting

1 part of a solution of sulphur dioxide saturated at room temperature with 1 part of water, and the tube is sealed.

The hydrolysis is carried out by heating the contents of the tube to 135°C. for 60 to 90 min. A convenient arrangement is to immerse the tube in a bath of boiling xylene which affords automatic temperature regulation. The equipment used consisted of a large vertical copper cylinder equipped with a water condenser and containing copper tubes into which the glass reaction tubes could be placed. Originally, a reaction time of 60 min. was used but it was later felt that for this work a period of 75 to 80 min. was preferable in order to insure complete hydrolysis of the locust bean gum.

When the reaction period is complete, the samples are removed from the bath and allowed to cool before recovery of the sugars is carried out.

Recovery of Sugars

The reaction tubes are opened by carefully breaking off the tops. The contents are transferred quantitatively to a fritted glass funnel and the filtrate is collected. The pulp residue should be broken up and thoroughly washed to insure complete removal of sugars. The filtrate containing the sugars in dilute solution is then concentrated and neutralized. Caution at this point of the operation is emphasized for the sugars are easily burned.

The filtrate containing the sugars is heated on a steam bath under a stream of air to aid evaporation. Barium carbonate is added to the hot solution to neutralize the excess sulphurous acid, as well as the small amount of sulphuric acid inevitably formed. Although the volume should be reduced to a few milliliters, the sample should not be taken to dryness at this point because of the danger of burning.

A small amount of analytical grade Celite is next added to the neutralized, concentrated sugar solution. The solution is filtered through a small cotton-asbestos filter (which has been washed with water prior to filtration) and the filtrate containing the sugars is collected. Again, washing is advised to insure a quantitative recovery of the sugars. At this point in the operation a known amount of a reference sugar (rhamnose was used here) is added to the sugars. Quantitative handling of the sugars is not required beyond this point until the final step (elution and oxidation). The entire sugar solution is next concentrated to a thin syrup for the separation of the sugars.

Separation of the Sugars

Separation of the sugars is accomplished by paper partition chromatography. The sugar syrup is laid down in a thin line across the paper strip from a fine, strong, capillary tube. Whatman no. 1 filter paper (4 by 24-in.) is used. The paper strip is irrigated in a tank with a pyridine-butanol-water system (3:10:3) for 44 to 48 hr. At the end of this period, the strip is dried and thin guide strips are cut from both edges. The guide strips are sprayed with a solution of aniline hydrogen phthalate (in butanol saturated with water) and placed in the oven for several minutes. Spots are formed where sugars are present and these serve to locate the corresponding sugars in the main portion of the strips. The rhamnose which moves rapidly will invariably be found near the bottom of the strip at the end of the first development period. The portion of the main strip which contains rhamnose is then cut off and the upper part of the strip is returned to the chromatographic tank for another 44 to 48 hr. In this way the rhamnose is easily separated and recovered in 2 days, whereas the galactose and glucose require 4 days of treatment. This procedure has been found satisfactory, since it gives good separations of glucose and galactose. Such separations frequently were not possible with 2 days' development. At the end of the second development period, a second set of guide strips are sprayed and the portion of the main sheet containing the galactose is cut out. A blank or control specimen containing no sugar is also cut out. The portions which have been cut out then contain the sugars to be oxidized for quantitative determination. Care should be taken that the samples represent corresponding portions of the width of the original chromatogram.

Determination of the Sugars

The sugars are recovered from the paper portions by the process of elution (*14*, *15*). One end of the small paper sample is held between two microscope slides at their ends. The slides in turn dip into a Petri dish filled with water so that, by capillary action, water is fed to the top of the paper sample. Water slowly flows down the paper flushing the sugars along with it. It has been established that the sugars follow the water interface very closely. When the water reaches the bottom of the strip, a small portion containing the sugar is cut off with scissors and allowed to fall into another Petri dish. This strip is then carefully transferred with forceps to a ground glass-stoppered reaction tube. The implements and Petri dish are rinsed and the rinsings are added to the tube so that quantitative transfer of the sugar is effected.

One milliliter of 0.25 molar sodium periodate is added to the reaction tube and the tube is stoppered. The mixture is heated on the steam bath for 10 min. The stopper is pulled open and the tube is cooled under a cold water tap. Three drops of Methyl Red indicator and 0.5 ml. of ethylene glycol are added and the tube is allowed to stand a few minutes for reaction of the ethylene glycol with the excess sodium periodate. The formic acid which is produced by periodate oxidation of the sugar is then titrated with very dilute alkali (0.001 to 0.005 N). The blank or control strip, the galactose strip, and the rhamnose strip are titrated in this manner. The relative amounts of galactose and rhamnose are found by subtracting the blank titration from each. The percentage of gum in a paper sample can be calculated by the following formula:

$$\text{Percentage of gum} = \frac{\left[\frac{(G - B)}{(R - B)(1.14)}\right](r)(100)}{\left[\frac{g}{100}\right](s)}$$

where

G = milliliters for galactose
B = milliliters for blank
R = milliliters for rhamnose
r = weight rhamnose added (grams)
g = percentage of galactose from gum
s = weight of sample (grams)
1.14 = conversion factor for rhamnose to be equivalent to a normal hexose sugar by periodate oxidation

LITERATURE CITED

1. Hunter, D., "A Papermaking Pilgrimage to Japan, Korea, and China," 150 pages, New York, Pynson Printers, 1936.
2. Broadbent, F. D., and Harrison, H. A., *Proc. Tech. Section, Paper Makers' Assoc. Gt. Britain Ireland* 21: 213–223 (1940).
3. Swanson, J. W., *Tappi* 33, No. 9: 451–462 (Sept., 1950).
4. Shriver, E. H., II, Webb, M. B., and Swanson, J. W., *Tappi* 33, No. 12: 578–586 (Dec., 1950).
5. Kubal, J. V., and Gralén, N., *J. Colloid Sci.* 3, No. 5: 457–471, (Oct., 1948).
6. Lew, B. W., Wolfrom, M. L., and Goepp, R. M., Jr., *J. Am. Chem. Soc.* 68: 1449–1453 (1946).
7. Dickey, E. E., Unpublished work.
8. Flood, A. E., Hirst, E. L., and Jones, J. K. N., *J. Chem. Soc.* 1948: 1679–1683.
9. Bourquelot, E., and Herissey, H., *Compt. rend.* 129: 228, 391 (1899).
10. Lew, B. W., and Gortner, R. A., *Arch. Biochem.* 1, No. 3: 325–338 (Feb., 1943).
11. Inglesias, G., *Anales soc. españ. fis. quim.* 33: 114 (1935).
12. Hirst, E. L., and Jones, J. K. N., *J. Chem. Soc.* 1948: 1278–1282.
13. Wise, L. E., Green, J. W., and Rittenhouse, R. C., *Tappi* 32, No. 7: 335–336 (July, 1949).
14. Dent, C. E., and Rimington, C., *Biochem. J.* 41: 240–253 (1947).
15. Leech, J. G., Acetolysis Products of Slash Pine Alpha-Cellulose Studied by Chromatographic Methods. Doctor's Dissertation. Appleton, Wis. The Institute of Paper Chemistry, 1952.

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The Effect of Different Pulps on the Biological Activity of Phenylmercuric Acetate

B. F. SHEMA and J. H. CONKEY

Ten different pulps were investigated for their effects on the biological activity of phenylmercuric acetate. It was found that, in general, the unbleached grades of pulp significantly reduced the biological activity of phenylmercuric acetate. It was also found that bleaching removes or chemically changes the inactivating principle in the pulp. For the Mitscherlich sulphite pulp it was found that the peroxide bleaching process does not remove or change the inactivating principle to the same degree as the hypochlorite bleaching process. The addition of alum to unbleached pulps usually increases the toxicity of phenylmercuric acetate whereas in some of the bleached pulps there is a significant reduction in biological activity. Alum in distilled water is more toxic to the test organism than when it is added to a 1% pulp suspension. The hemicelluloses of loblolly pine and black spruce have no effect upon the biological activity of phenylmercuric acetate. The biological activity of phenylmercuric acetate is reduced by such lignin complexes as native lignin, alkali lignin, thiolignin, and calcium lignosulphonate.

THERE are many factors which influence the growth and development of objectionable forms of microorganisms in wet pulp and in pulp and paper mill systems. Some of these factors have no significant effect on the biological activity of a particular slime control agent, whereas other factors may increase or decrease the biological activity of the material in the mill system. Although these factors are usually considered in planning the treatment regime and in determining the most effective dosage rate for a given mill system, the independent effects of these factors on the biological activity of a slime control agent have not been adequately investigated. However, the effect of pH on the biological activity of some of the organomercurials, chlorinated phenols, and a quaternary ammonium compound has been determined (*1, 11*).

Because effective microorganism control with chemical toxicants is dependent upon the initial toxicity of the material and on the amount of the chemical which remains biologically active in the mill system, it is desirable to determine the effect of various factors on the biological activity of slime control agents. At the present time there is a difference of opinion regarding the adsorption of phenylmercuric acetate on pulp and on the biological activity of slime control agents in the presence of pulp. Lundgren (*7*) has stated that 90% of the phenylmercuric acetate added to the mill system remains with the fiber and that the remaining 10% evaporates or goes to the sewer. Pehrson and Lindberg (*11*) used a biological method to determine the adsorption of phenylmercuric acetate on groundwood, unbleached sulphate, and sulphite pulp. Their results show that the groundwood fibers adsorb more of the toxicant than the chemical pulp fibers. It was found that a 2% suspension of groundwood pulp will adsorb about 0.4 mg. of the organomercurial per gram of pulp. In the presence of aluminum sulphate, however, this quantity is considerably reduced. The authors also found that only 5% of the mercurial can be detected in the white water from a 2% groundwood pulp suspension which was mixed with 0.001% phenylmercuric acetate, whereas about 50% remained in the white water when aluminum sulphate was added to the pulp. These authors concluded that phenylmercuric acetate is completely sorbed by the fibers at the concentrations used in groundwood mills; the disinfectant therefore remains in the pulp laps and protects them against fungus attack. In the paper mill, on the other hand, a great percentage of the mercurial is lost in the white water. Buckman (*3*) found that sufficient mercurial was retained by the fiber to protect it from gross fungus attack when the mercurial was added directly to the pulp mill system. Gillespie (*5*) has pointed out that unbleached pulps will adsorb more phenylmercuric acetate than bleached pulps. Consequently, it is more difficult to maintain inhibiting concentrations in unbleached pulps than in bleached pulps. Halliday (*6*) reported that sized eucalypt kraft pulp significantly reduced the biological activity of phenylmercuric ace-

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te. He is of the opinion that phenylmercuric acetate substantive to cellulose, and that in its adsorbed state is biologically inactive. He concluded, therefore, at the application of phenylmercuric acetate as an ntislime measure in paper mill systems is of very oubtful value. Gadd (*4*) using *Bacillus subtilis* as the st organism found that a 2% groundwood pulp suspension had no effect on the biological activity of phenylercuric acetate. He therefore concluded that the adrbed phenylmercuric acetate is as toxic as the unlsorbed portion. Brown and Harrison (*2*) found no vidence that would indicate that a sterile paper is roduced by the adsorption of mercury. These authors ated that, in view of the fact that there is no adsorpon of mercury by the cellulose fiber, the only mercury st is that in the effluent, together with a negligible nount contained in the water in the wet web. McKee ?) also is of the opinion that the phenylmercuric ion is ot adsorbed by the cellulose; for this reason, he beves that phenylmercuric acetate persists in the mill stem and is effective at very low dosages. Shema, nderson, and Appling (*12*) have shown that there is a duction in the biological activity of ethylmercuric osphate in a groundwood pulp mill system. This udy showed that biologically active ethylmercuric osphate persists in the mill system in greater amounts d for longer periods of time immediately after a washo than later in the week. It was also demonstrated at there is a reduction in the biological activity of the xicant with an increase in amount of dissolved and spended solids in the white water. Mardon and edder (*9*) found that 30% of the phenylmercuric acete added to a mill system is adsorbed by the fines in e white water and that most of the adsorbed material biologically inactive. In another study (*10*), the me authors found that ethoxy ethylmercury phosate is adsorbed by unbleached sulphite and that apoximately 85 to 90% of the adsorbed material is ologically inactive.

From this review of the literature, it is evident that ere is a difference of opinion regarding the biological tivity of phenylmercuric acetate and other organoercurials in the presence of cellulosic materials.

Therefore, the object of this investigation is to deterine the effect of different pulps on the biological activy of phenylmercuric acetate.

MATERIALS AND METHODS

The bleached and unbleached grades of pulps used in is study are representative samples of the process sed in the mills from which the samples were received. he samples of bleached pulp were collected on the me day as the unbleached pulp. Immediately after e pulps were received at The Institute of Paper hemistry, they were allowed to air dry for at least 1 eek before they were studied for their effect on the ological activity of phenylmercuric acetate. The ulps studied for their effect on the biological activity phenylmercuric acetate are as follows: (1) bleached d unbleached Mitscherlich spruce, (2) two different mples of bleached and unbleached jack pine kraft,) bleached and unbleached loblolly kraft, (4) unleached poplar neutral sulphite, (5) bleached and nbleached poplar groundwood, (6) bleached and unleached groundwood (70% spruce, 30% balsam), (7) two different samples of bleached rag, and (8) cotton linters.

A medical grade of phenylmercuric acetate was used throughout this study. The alum was a commercial grade of papermaker's alum. In all cases the phenylmercuric acetate and alum were dissolved in distilled water before they were added to the pulp suspension.

The effect of various pulps on the biological activity of phenylmercuric acetate was determined by the percentage survival of the bacterium *Aerobacter aerogenes* in a 1% pulp suspension. The pulp suspension was prepared by disintegrating the air-dry pulp in the desired amount of sterile distilled water in an Oster mixer for approximately 5 min. A sufficient amount of 1% pulp suspension was prepared so that each 250-ml. Erlenmeyer flask contained 100 ml. of the pulp suspension. Proper aliquots of phenylmercuric acetate were added to each flask to give a final concentration of 0.1 and 0.5 p.p.m. of the toxicant. Immediately after the phenylmercuric acetate was mixed with the contents of the flask, 1 ml. of a 1% solution of alum was added to the contents of those flasks in which the effect of alum was studied. After thoroughly mixing the contents of each flask, the pulp suspension was inoculated with 1 ml. of a bacterial suspension of *Aerobacter aerogenes.*

Immediately after inoculation, the controls (those without phenylmercuric acetate) were plated for their bacterial count. Therefore, for each set of flasks there were six controls or a control for each set of three flasks. After the flasks were inoculated with the test organism, they were allowed to incubate at 30°C. for 3 hr. At the end of this period of incubation, the contents of each flask was plated for its bacterial content in Difco nutrient agar. Plate counts were made after 48 hr. of incubation at 37°C.

The bacterial suspension of *Aerobacter aerogenes* is prepared by washing the growth from the surface of a Difco nutrient agar bottle slant with 10 ml. of sterile water. (The bottle slant is prepared by slanting 20 ml. of nutrient agar in an 8-oz. square Pyrex dilution bottle.) The 10-ml. bacterial suspension is diluted with 89 ml. of sterile distilled water. The culture used for the inoculum was grown for 24 hr. at 37°C. For each series of tests, the sensitivity of the test organism was determined with two different procedures. The first procedure consists essentially of streaking two loopfuls of the inoculum on the surface of nutrient agar which contains different concentrations of phenylmercuric acetate. In this instance, the growth of this particular strain of *Aerobacter aerogenes* is completely inhibited at a concentration of 0.00015% by weight or 1.5 p.p.m. The sensitivity of the test organism was also determined in an aqueous system. Briefly, this procedure consists of adding 1 ml. of the inoculum to 250-ml. Erlenmeyer flasks which contain an aqueous solution of 0.1 and 0.5 p.p.m. of phenylmercuric acetate, respectively. In all cases the final volume in each flask is 100 ml. Immediately after inoculation the control flask (no phenylmercuric acetate) is plated for its bacterial content. After 3 hr. of contact at 30°C., the contents of each flask is plated for its bacterial content and the percentage kill is determined. Under these conditions, a percentage kill of 95 to 100% at a

concentration of 0.1 p.p.m. of phenylmercuric acetate in distilled water is considered satisfactory.

RESULTS AND DISCUSSIONS

The effect of various pulps on the biological activity of a slime control agent may be very significant from the standpoint of selecting the most effective dosage rate and from the standpoint of the most economical use of that particular slime-control agent. That is, under certain mill operating conditions a given dosage rate will be effective in controlling the growth of objectionable forms of microorganisms; however, should the furnish be changed from bleached to unbleached pulp and/or other changes made in the furnish, it is possible for the dosage rate to become less effective or completely ineffective because of the inactivating principle inherently present in the pulp or in some other component of the furnish. This inactivating principle may reduce the biological activity of the slime-control agent to the extent that stimulatory concentrations will result which will increase rather than decrease the number of microorganisms in the mill system. Therefore, under these conditions, the addition of a slime-control agent may result in an aggravation rather than an alleviation of the slime condition in that particular mill system. However, should the initial dosage rate be significantly greater than this threshold value, adequate slime control should result.

On the other hand, if this initial dosage rate is sufficiently high to compensate for variations in furnish, it is possible that more slime control agent is used than is required to give satisfactory slime control during those periods when the furnish has no inactivating principle. The difference in the dosage rate between furnishes with and without the inactivating principle may be sufficiently great to effect a considerable saving in the cost of slime control during those periods when no inactivating principle is present in the pulp. It follows also that, by overtreating a mill system which has no biological demand, the cost of slime control may be excessive unless the effect of that particular furnish has been determined for those specific operational conditions.

The effect of ten different pulps on the biological activity of phenylmercuric acetate is summarized in Table I. The percentage kills recorded are the averages of five separate tests with the exception of the tests made in distilled water which are the averages of 50 trials.

These data show that the unbleached grades of kraft, neutral sulphite, and groundwood significantly reduce the biological activity of two concentrations of phenylmercuric acetate. This effect of the pulp on the biological activity of the phenylmercuric acetate is more pronounced at 0.1 p.p.m. than at 0.5 p.p.m. Unbleached loblolly kraft has the greatest effect on the biological activity of this slime-control agent. One-tenth part per million of this agent in a 1.0% pulp slurry of loblolly pine has no effect upon its bacterial content, whereas 98% kills are obtained at the same concentration of this agent in distilled water. At 0.5 p.p.m. only 42% of the bacteria in the flask were killed. The two jack pine kraft pulps were similar to loblolly kraft in their reaction to this slime-control agent. At 0.1 p.p.m. of phenylmercuric acetate, jack pine sample A produced only 3% kill, whereas jack pine sample B produced less than 1.0% kill. However, at 0.5 p.p.m. the percentage kills for the two jack pine kraft pulps are approximately twice the kills obtained for loblolly kraft. There is also a minor difference in percentage kills between the two jack pine kraft pulps. It is possible that this difference in percentage kill may be only the result of the degree of washing of the two pulps. At lower concentration of phenylmercuric acetate, sample B has a greater inactivating effect than sample A, whereas, at 0.5 p.p.m. sample A produces the greatest inactivating effect. At the lower concentration the difference in kill between the two treated pulps is not significantly greater than the difference between the untreated pulp. However, at the highest concentration of the toxicant the difference should be significant.

The unbleached sulphite pulp has approximately the same effect on phenylmercuric acetate as sample B of the jack pine kraft. The aspen neutral sulphite pulp also inactivates the biological activity of the slime control agent. This pulp has less effect on the biological activity of the toxicant at 0.1 p.p.m. than either of the jack pine kraft pulps or the sulphite pulp. However, at 0.5 p.p.m. of the toxicant the neutral sulphite pulp produces a greater effect than either of the jack pine kraft pulps and the sulphite pulp. (The loblolly kraft pulp in the presence of 0.5 p.p.m. of the toxicant produces a greater effect than the neutral sulphite pulp.)

Unbleached aspen groundwood has a greater effect on the biological activity of phenylmercuric acetate than the unbleached groundwood which contained 70% spruce balsam and 30% aspen.

In the case of the bleached pulps, high percentage kills are obtained with 0.1 p.p.m. of phenylmercuric acetate. The percentage kills are approximately the same as those obtained with phenylmercuric acetate in the absence of pulp. There are, however, two exceptions—namely, one sample of bleached rag and one of loblolly kraft. In both cases, however, the demand was satisfied at the highest concentration of phenylmercuric acetate. Therefore, these data show that bleaching reduces or completely destroys the principle which reduces the biological activity of phenylmercuric acetate.

Sample A of bleached rag was very toxic to the test organism *Aerobacter aerogenes* under the conditions of this test. The reason for this initial toxicity was not determined. However, the possibility of chlorine or chloride as the toxic agent was investigated and it was found that these materials were not present in sufficient amounts to account for this toxicity. This particular sample of bleached rag contained some inactivating principle because the percentage kill was relatively low at 0.1 p.p.m. of phenylmercuric acetate. The other sample (B) of the bleached rag pulp was also toxic to *Aerobacter aerogenes* but not in the same order of magnitude as sample A. Sample B of the rag pulp apparently does not contain an inactivating principle because 98% of the test organisms were killed at 0.1 p.p.m. of phenylmercuric acetate. Cotton linters apparently has no effect on the biological activity of phenylmercuric acetate.

The effect of alum on the biological activity of

Table I. The Effect of Different Bleached and Unbleached Grades of Pulp on the Biological Activity of Phenylmercuric Acetate

Type of substrate	Concentration of phenylmercuric acetate in p.p.m.					
	0.0		0.1		0.5	
	Percentage kill of the test organism Aerobacter aerogenes					
	No alum	*0.01% alum*	*No alum*	*0.01% alum*	*No alum*	*0.01% alum*
Distilled water	2[a]	49[a]	98[a]	91[a]	99[a]	97[a]
Kraft						
Unbleached jack pine sample A	6	63	3	64	80	83
Bleached jack pine sample A	7	16	97	75	99	92
Unbleached jack pine sample B	3	50	1	55	88	79
Bleached jack pine sample B	7	19	99	68	99	97
Unbleached loblolly	3	30	0	29	42	81
Bleached loblolly	2	21	88	92	99	96
Sulphite						
Unbleached spruce sulphite (Mitscherlich)	3	35	5	52	88	99
Bleached spruce sulphite (Mitscherlich)	3	39	95	99	99	99
Semichemical						
Unbleached neutral sulphite (aspen)	15	20	18	3	66	65
Groundwood						
Unbleached aspen	17	11	34	86	73	98
Bleached aspen	7	14	92	82	99	96
Unbleached 70% spruce balsam 30% aspen	20	50	70	99	99	99
Bleached 70% spruce balsam 30% aspen	3	17	93	96	97	99
Bleached rag						
Sample A	76	81	72	97	98	99
Sample B	32	73	98	95	99	99
Cotton linters	18	52	98	86	99	97

[a] Average of 50 trials.

phenylmercuric acetate in the presence of different pulps was also studied. The procedure for the study was the same as that followed in the study of the effect of various pulps on the biological activity of phenylmercuric acetate. The trials with alum were made concomitantly with the other trials. Therefore, the conditions for each trial with and without alum were identical. The data on the effect of alum on the biological activity of phenylmercuric acetate are also summarized in Table I.

One hundred parts per million of papermaker's alum in distilled water kills 49% of the bacteria added to the flask. However, the addition of the same amount of alum to 0.1 and 0.5 p.p.m. of phenylmercuric acetate reduces its biological activity by 7 and 2 percentage points respectively.

The action of alum on the toxicity of phenylmercuric acetate in the presence of pulp is very interesting. As expected, the addition of alum to bleached and unbleached pulp increases the percentage kill of the test organism. However, in only one case is this percentage kill greater than the percentage kill obtained in water. This effect is noted for sample A of unbleached jack pine kraft.

The addition of alum to unbleached aspen groundwood pulp results in a kill which is lower than the kill obtained in the pulp alone. Therefore, the toxicity of both the pulp and the alum is reduced in such a mixture. In general, higher percentage kills are obtained when alum is added to the unbleached grade of the pulp than when it is added to the bleached grades of the same pulp. In the case of sample A of unbleached jack pine kraft, 63% of the bacteria were killed in the presence of alum, whereas in the bleached grade of the same pulp only 16% of the bacteria were killed. With the exception of unbleached aspen groundwood the bleached pulp has the greatest effect upon the biological activity of papermaker's alum.

The addition of the alum to the different pulps has a significant effect upon the biological activity of phenylmercuric acetate. The addition of alum to 0.1 p.p.m. of phenylmercuric acetate results in a reduction in biological activity of the toxicant in the presence of both bleached jack pine kraft pulps, unbleached neutral sulphite pulp, bleached aspen groundwood, and sample B of bleached rag and cotton linters. Also, significant increases in activity of the toxicant are noted for some of the pulps. For example, at 0.1 p.p.m. of the toxicant in the presence of unbleached jack pine kraft (sample A) the addition of alum increases the percentage kill from 3 to 64%, whereas for the bleached pulp the kill is reduced from 97 to 75%; although the same general trend is observed at 0.5 p.p.m. of the toxicant, the difference in percentage is not as great.

Because the unbleached pulps have a different effect upon the biological activity of phenylmercuric acetate it was deemed desirable to determine the amount of the toxicant necessary to satisfy the demand of the pulp. The experimental methods used in this phase of the study are the same as those described previously. The results reported are the averages of five separate trials. From Table I it would be reasonable to conclude that sample B of unbleached jack pine kraft contains more of the inactivating principle than sample A. However, this is not the case because 1.1 p.p.m. of phenylmercuric acetate for sample B was required to give the same kill as 0.1 p.p.m. in distilled water, whereas 0.9 p.p.m. of the toxicant is required for sample B. Loblolly kraft would be expected to contain the greatest amount of the inactivating principle because of the low percentage kill of the test organism. For this grade of unbleached pulp, 2.7 p.p.m. of phenylmercuric acetate was required to give the same kill as in distilled water. That is, 27 times more of toxicant is required in the presence of this pulp to give the same percentage kill as is required in distilled water. For unbleached Mitscherlich sulphite 1.5 p.p.m. of the toxicant is required, whereas 2.3 p.p.m. is required for unbleached neutral sulphite. Unbleached aspen groundwood requires 1.1 p.p.m. of the toxicant to satisfy its demand. To determine whether the inactivating principle is water soluble, unbleached loblolly kraft and unbleached aspen neutral sulphite were extracted with hot water for 16 hr. in a soxhlet. The hot water ex-

Table II. The Effect of Peroxide Bleaching on the Biological Inactivating Principle in Unbleached Sulphite Spruce (Mitscherlich)

Treatment	Concentration of phenylmercuric acetate in p.p.m. 0.0		0.1		0.5	
	Percentage kill of the test organism Aerobacter aerogenes					
	No alum	0.01% alum	No alum	0.01% alum	No alum	0.01% alum
Distilled water only	2[a]	49[a]	98[a]	91[a]	99[a]	97[a]
Unbleached spruce sulphite	3	35	5	52	88	99.9
Hypochlorite bleached pulp	3	39	95	99	99	99
Peroxide bleached pulp neutralized with sulphur dioxide	1	6	69	96	98	99
Peroxide bleached pulp	2	8	78	92	99	99

[a] Average of 50 trials.

traction did not eliminate the inactivating principle in loblolly kraft; as a matter of fact, the desired kill was obtained with 2.9 p.p.m. of the toxicant, which is 0.2 p.p.m. greater than that required for the unwashed pu'p. However, washing significantly reduced the amount of inactivating principle in the unbleached neutral sulphite pulp. In this case the washed pulp required 1.3 p.p.m. of the toxicant as compared to 2.3 p.p.m. for the unwashed pulp.

To determine whether solutions of phenylmercuric acetate are biologically inactivated by unbleached pulps, preliminary experiments were made by determining the biological activity of filtrates with a bioassay technique. The technique used is that suggested by Shema, Anderson, and Appling (*12*). In these tests it was found that approximately 99% of the phenylmercuric acetate was recovered in the filtrate from bleached loblolly pine, whereas no biologically active phenylmercuric acetate was recovered from unbleached loblolly pine. It is possible that a very small amount of biologically active phenylmercuric acetate is present in the system since the lowest concentration which can be detected with a reasonable degree of accuracy is 0.07 p.p.m. The data show that in the case of bleached loblolly pine the phenylmercuric acetate is not adsorbed on the fibers and that it remains biologically active, whereas it may or may not be adsorbed by the unbleached pulps. The phenomenon of adsorption of phenylmercuric acetate by these pulps is a subject of another investigation.

To obtain some indication of the nature of the biological inactivating principle, various materials were tried for their activity in the presence of phenylmercuric acetate. Preliminary experiments show that the hemicelluloses from loblolly and black spruce have no effect upon the activity of this toxicant. Native lignin has a significant effect upon the activity of phenylmercuric acetate; however, practically all of the inactivating principle is satisfied at 0.5 p.p.m. The addition of alum to native lignin completely satisfies the inactivating principle at 0.5 p.p.m. of the toxicant. Alkali lignin has only a very slight effect upon the biological activity of this slime control agent. Thiolignin has a significant effect on the biological activity of phenylmercuric acetate at 0.1 p.p.m., but at 0.5 p.p.m. it has no effect. Calcium lignosulphonate has a pronounced effect on the activity of phenylmercuric acetate; at 0.5 p.p.m. only 61.0% of the test organisms were killed in the presence of this material. The amount of these materials used was calculated on the basis of the amount of hemicellulose and lignin present in the respective pulps. It was assumed that loblolly and spruce contains approximately 8.0% hemicellulose. For lignin it was assumed that groundwood contains approximately 30.0% native lignin; the sulphite pulps contain 3.0% calcium lignosulphonates, and the alkaline cooks contain 6.0% alkali lignin and/or thiolignin.

The effect of peroxide bleaching on the inactivating principle was determined for the Mitscherlich sulphite spruce pulp. The unbleached pulp was bleached with peroxide to the same brightness as the hypochlorite bleached pulp. A portion of the peroxide bleached pulp was neutralized with sulphur dioxide to determine if this method of neutralization has any effect on the activity of this toxicant. The experimental data presented in Table II are the averages of six separate trials.

These data show that bleaching with peroxide removes or inactivates a large portion of the mercury inactivating principle in sulphite pulp. However, the peroxide bleaching process is not as effective as the hypochlorite bleaching process. The difference in percentage kill of the test organism between the two bleaching processes is significant at the 0.1 p.p.m. level. At 0.5 p.p.m. the difference in percentage kill is small and it is not considered significant. These results further substantiate the results obtained with the different lignins—that lignin affects the biological activity of phenylmercuric acetate. However, the entire inactivation cannot be ascribed to the activity of lignin on this toxicant. It is interesting to note that only 6.0 and 8.0% of the test organisms were killed in the presence of this bleached pulp and alum. This is a marked reduction from the kills obtained in either the unbleached pulp or the hypochlorite bleached pulp. It does not seem likely that pH is responsible for this difference because the pH varied only from 4.2 to 4.6 between the unbleached and the bleached grades of this pulp.

LITERATURE CITED

1. Appling, J. W., McCoy, J. F., and Shema, B. F., *Paper Trade J.* 124, No. 22: 143–154 (May 29, 1947).
2. Brown, C., and Harrison, H. A., *Paper-Maker (London)* 113: TS 7–8, 17–19; 114: TS 2, 8 (1947).
3. Buckman, S. J., *Tappi* 32, No. 3: 129–144 (March, 1949).
4. Gadd, G. O., *Paper and Timber (Finland)* 33, No. 3: 49–52 (March, 1951).
5. Gillespie, A. G., *Paper Mill News* 72, No. 11: 18, 52 (March 12, 1949).
6. Halliday, W. T., *Australian Pulp and Paper Ind., Tech. Assoc. Proc.* 4: 242–249 (1950).
7. Lundgren, N., *Svensk Papperstidn.* 52, No. 9: 221–226 (1949).
8. McKee, W. N., *Paper Ind.* 31, No. 6: 684–686 (June, 1949).
9. Mardon, J., and Pedder, D., *Pulp Paper Mag. Can.* 53, No. 4: 122–128 (March, 1952).
10. Mardon, J., and Pedder, D., *Pulp Paper Mag. Can.* 54, No. 11: 131–133 (Oct., 1953).
11. Pehrson, S. O., and Lindberg, N. J., *Svensk Papperstidn.* 52, No. 22: 560–562 (1949).
12. Shema, B. F., Anderson, J. B., and Appling, J. W., *Tappi* 32, No. 11: 489–492 (Nov., 1949).

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A Simplified Moisture Equilibrium Apparatus

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A simple apparatus for the determination of the hygroscopic equilibrium of a foodstuff is described.

THE determination of the hygroscopic equilibrium of a foodstuff is an important consideration in the development of a proper package. The moisture content of dry foods in particular varies directly with the surrounding relative humidity. This relationship may be represented graphically on moisture equilibrium curves. Temperature is also an important factor for at a constant relative humidity the moisture content of a food material will vary inversely with the temperature.

Two of the most widely recognized methods of determining moisture equilibrium curves for food products are those of Wink (*3*) and Landrock and Proctor (*1*). These are described in detail in Packaging Institute Test Procedures for Determination of Humidity-Moisture Equilibria of Food Products (*2*). Although these methods are considered satisfactory in their results, they have certain disadvantages, such as the need for specialized equipment and, for many foods, a lengthy test period. To obviate the special humidity chambers required in these methods, a simple, easily constructed humidity chamber has been devised.

A glass jar with a metal screw cap is used as a humidity chamber. A pint Ball freezing jar with a two-piece lid is satisfactory. A strip of copper sheeting (6 by $^1/_2$ in.) is bent to form a bracket which will support a weighing dish. The weighing dish should be of such a size that it fits readily inside the humidity jar or container and can be weighed on an analytical balance. The copper bracket is soldered to the end of a piece of soft wire ($3^1/_2$ in. long), which is resistant to corrosion. The other end of the wire is soldered to the inside of the jar top. A diagram of the complete assembled unit is shown in Fig. 1. The remaining apparatus necessary includes an analytical balance and a constant temperature cabinet or room.

This humidity chamber may be used with either Wink's or Landrock's method. To maintain a constant humidity, the appropriate saturated salt solution is placed in the jar to a depth of about 1 in. Various concentrations of sulphuric acid may also be used for this purpose.

The sample of food to be studied is weighed into the weighing dish. A thickness of no more than 2 mm. spread evenly over the bottom of the dish is recommended for powdered materials. The weighing dishes are then placed in brackets inside the humidity jars, the jars sealed tightly, and the entire unit placed in a constant temperature cabinet or room. The dishes may be taken out of the jar chambers, covered, and weighed quickly on an analytical balance.

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The suggested humidity chambers offer several advantages to the average food laboratory. The jars are readily available and inexpensive so that relatively large numbers can be kept on hand. Unlike Wink's dishes, these modified jars can be stacked on shelves, taking up less space. No change need be made on the analytical balance, thus leaving it free for other

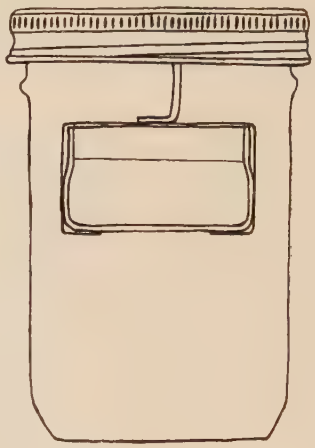

Fig. 1. Humidity chamber showing weighing dish in place

laboratory weighings. The awkward procedure of handling the bulky Wink chambers in the analytical balance is eliminated. The simplicity in modifying these jars into humidity chambers is in marked contrast to the more difficult operations required to make and assemble the humidity chambers described by Wink. In addition, the possibility of disturbing the sample dishes during test storage is not so great as in the humidity chamber described by Landrock.

This proposed technique requires that the food sample be weighed outside its controlled humidity atmosphere. Humidity conditions in the balance room at considerable variance with jar humidity will cause some loss or gain in moisture during the weighing period. This point is discussed in some detail in the Landrock method. However, with some experience or practice these weighings can be made rapidly enough so that the error involved will not materially affect the final equilibrium humidity curve.

This proposed apparatus has been checked against that used in Wink's method for a number of foodstuffs with good results.

LITERATURE CITED

1. Landrock, A. H., and Proctor, B. E., *Food Tech.* 5, No. 8: 322 (1951).
2. Packaging Institute, Procedure for Determination of Humidity-Moisture Equilibria of Food Products, Packaging Institute Test Procedure, P. I. Food 1p-52, 8 pages, New York, N. Y. (1952).
3. Wink, W. A., *Ind. Eng. Chem., Anal. Ed.* 18: 251 (1946).

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Chipper Operation

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Chipper operation and maintenance are very important factors in the production of sawdust and chip uniformity. On four-knife chippers: sawdust varies directly with the speed, percentage of chips of the desired size increases with decreasing speed, power per cord varies directly with the speed, and paper strength increases with decreased speed. On four or multiple-knife chippers, knife sharpness has a marked effect on sawdust and power. Chipper condition has an important bearing on sawdust and chip quality. Using chipper to capacity reduces sawdust and increases chip uniformity. Knives should be changed rather than filed. The bedplate should be kept sharp and in close adjustment to the knives.

IRRESPECTIVE of mill location, management is often reluctant to recognize the importance of chip preparation, both from the standpoint of wood loss and pulp quality. Since it is often difficult to secure an appropriation for needed repairs or improvements in the woodroom, it is necessary to see that the equipment available is properly maintained and operated if excessive wood losses and poor chip quality are to be avoided. Chipper design, whether four or multiple-knife, is not of prime importance in producing satisfactory chips. Any chipper made by a reliable manufacturer will produce good chips but only if it is properly operated and maintained.

Assuming a wood cost of $30 a cord, a reduction in sawdust of 1% means a wood saving of 1 cord in 100 and about 50¢ per ton of pulp. It is not uncommon for total sawdust, i.e., that removed by the screens plus that remaining in the chips and passing 0.185-in. mesh, to run over 5%. In any reasonably good chipper operation this figure should not exceed 2.5% and should be even less.

Accompanying the reduction of sawdust, by whatever means, there is usually an increase in chip uniformity, less fines, slivers, and slugs, with a reduction in pulp screenings. In one case, this reduction in tailings alone amounted to $1.30 a ton, plus $1.50 a ton due to less sawdust being produced.

Theoretically, the amount of sawdust made will vary indirectly with the chip length; actually it does not quite reach the theoretical figure. As an example, the observed results over two 1-month periods showed 26% less sawdust when the knives were set for a 1-in. chip as compared with a $^5/_8$-in chip.

Chip uniformity and the absence of small chips tends to improve pulp uniformity and strength. Another factor which is often overlooked is the effect of poor chipper operation on the bruising of one end of the chip. At present, some bruising cannot be avoided but pulping tests have indicated that a 25% loss in strength is caused by bruising. While this cannot be overcome poor chipper operation can appreciably increase this strength loss.

Sawdust is of little or no value for pulp and often is practically unchanged by the pulping chemicals. The reason lies in the fact that much of the sawdust is compression wood which has very poor strength and may not even be penetrated by the cooking liquor.

A study at five mills, covering 10 four-knife chippers, was undertaken to determine the effect of speed, knife sharpness, and angle of the cutting edge on total sawdust and power. One chipper was 84 in., the rest 88 in., and only two had antifriction bearings.

Figure 1 shows the effect of speed on total sawdust (through 0.185-in. mesh) and very clearly illustrates what can be accomplished in wood saving by a reduction of chipper speed. In one case there is an indication that sawdust decreases as speed is increased over 260 r.p.m. and it would have been interesting if higher speeds on this particular chipper had been investigated. A number of years before this study was made, Heritage, in an unpublished report, concluded that 700 cuts a minute or 175 r.p.m., produced the best results with respect to both sawdust and chip uniformity. In other installations, two 110-in. four-knife chippers operating at 180 r.p.m. produced 1.7% sawdust and knots, another 0.6% total sawdust. In Sweden, it is claimed that total sawdust and knots do not exceed 0.5%. On the other hand, it has been reported that excellent chips and low sawdust have been produced with a four-knife chipper at 440 r.p.m. However, from a mechanical point of view, the lower speed is to be preferred. Where it was possible to keep the chipper spout full at the higher speeds, capacity decreased with the speed as would be expected. Chip uniformity improved as the speed decreased.

Increase in pulp strength was mentioned as one of the results of reducing chipper speed. In a particular mill, the speed of a four-knife chipper was reduced from 275 to 200 r.p.m., accompanied by a reduction in sawdust (through $^1/_4$-in. mesh) from 7 to 3.25%. At the same time, paper machine bursting strength increased from 82 to 87.5%, both figures the average of 8 months' experience before and after the change.

Power per cord was also affected by speed reduction, the greatest difference was found on one chipper with babbitted bearings, from 7.5 to 5.5 kw.-hr. for a reduction in speed from 285 to 185 r.p.m. The results for four of the chippers under test are shown in Fig. 2.

The next item studied was the effect of knife sharpness on power and sawdust, irrespective of speed. For sharp knives the average is 5.52 kw.-hr. per cord while for dull knives the figure is 5.93 kw.-hr. Total sawdust when the knives were sharp averaged 2.59% but when dull, 3.57%. In other words, dull knives cost 0.5 kw.-hr. per cord more than sharp and produce 1% more sawdust.

It is quite common practice to file knives at least once before changing. Figure 3 shows the fallacy of so doing. The top plot shows what happens to sawdust when these particular knives were not changed for 4

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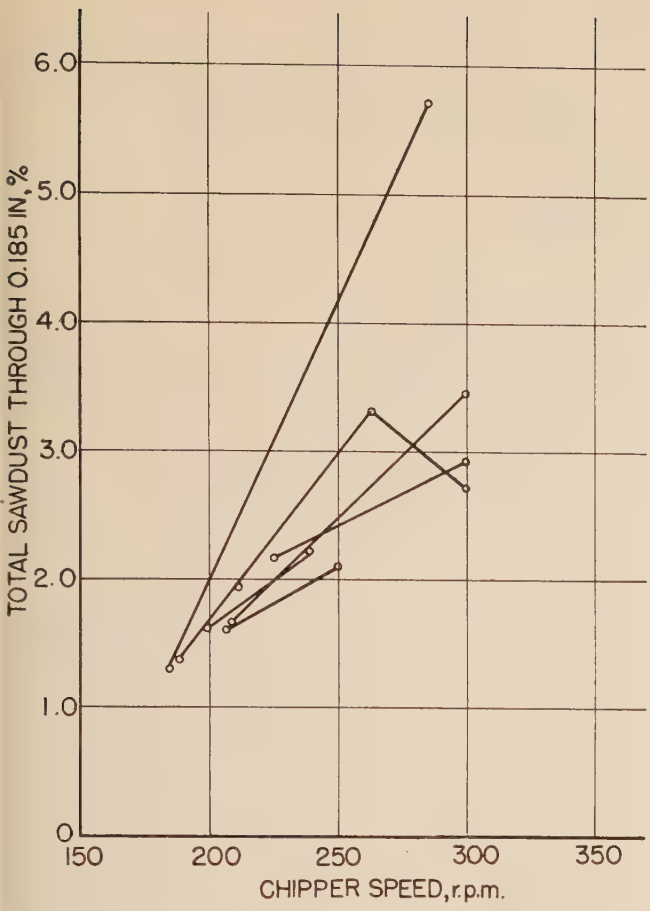

Fig. 1

hr. on chippers operating at 250 and 208 r.p.m., respectively. The middle plot illustrates what happens when knives are filed at the end of 2 hr., and the last plot the result when knives were changed at the end of 2 hr.—a reduction of about $^1/_4$% in sawdust over filing. The time lost in filing was 6 min. and in changing knives 12 min., so for a cost of 6 min. say 0.2% sawdust was saved worth, with wood at $30, approximately $4.20 for each 2 hr. of chipping. It also is noticed that in these plots, the effect of slower speed on sawdust is illustrated.

The conclusion to be drawn from the foregoing is that the knife, which will keep its edge the longest, is the one to buy, irrespective of first cost. Further, it has been found that the cheap knife will actually cost more per cord. On a four-knife chipper, knife life will vary from about 500 chipping hr. for the cheap knife to over 2000 hr. for the better steels. An average of tests taken every 30 min. during the day and covering 5 days showed that the more expensive knife produced 0.5% less sawdust than the cheaper.

It has been emphasized that, to secure the best results, any chipper must be properly operated and maintained. This applies to the multiknife as well as the four-knife. To illustrate, tests on two four-knife chippers, identical except for physical condition, showed that the poorer chipper made 4.2% sawdust while that in good condition produced 2.5%.

The multiple-knife chipper has advantages over the four-knife but it is not a cure-all. Sawdust is no less than can be secured by a four-knife in good condition and properly operated. Production, of course, can be greater and often chips are more uniform but in order to maintain these advantages, the multiple-knife must be maintained. One of the items affecting chip quality is the degree of wear on the face plates. Before changing worn face plates, chip analysis showed 26.9% over $^3/_4$ in. and 62.7% through $^3/_4$ and on $^3/_8$ in. After new face plates were installed the fraction on $^3/_4$ in. was reduced to 3.3% and that through $^3/_4$ and on $^3/_8$ in. was increased to 79.6%. Sawdust was reduced by 2.0%.

The rate of chipper feed is also important in its effect on chip quality. The spout should always be kept full, particularly on a four-knife. Below are the results secured on a test run of measured cords put through a 10-knife chipper at two rates: speed was 325 r.p.m. and knives were set for a $^5/_8$ in. chip.

Retained on	*At 21.6 cords/hr. %*	*At 50.7 cords/hr., %*
1.050 in.	2.0	0.4
0.742 in.	20.1	12.8
0.525 in.	43.3	51.3
0.371 in.	16.4	19.5
0.263 in.	6.0	6.9
0.126 in.	3.4	3.9
Sawdust	1.5	1.0

So far, nothing has been said about the bedplate which is also important in the production of good chips. While it is not necessary to change bedplates as often as knives, they should be changed when dull. How often will depend on the hardness of the edge and the wood quality. With a stellited edge the bedplate need not be changed oftener than, say, every 1500 to 2000 cords. A rounded edge results in more slivers and sawdust but unfortunately no test runs are known where this factor has been studied.

Close adjustment of the bedplate to the knives is as important as sharpness. It should be brought up just

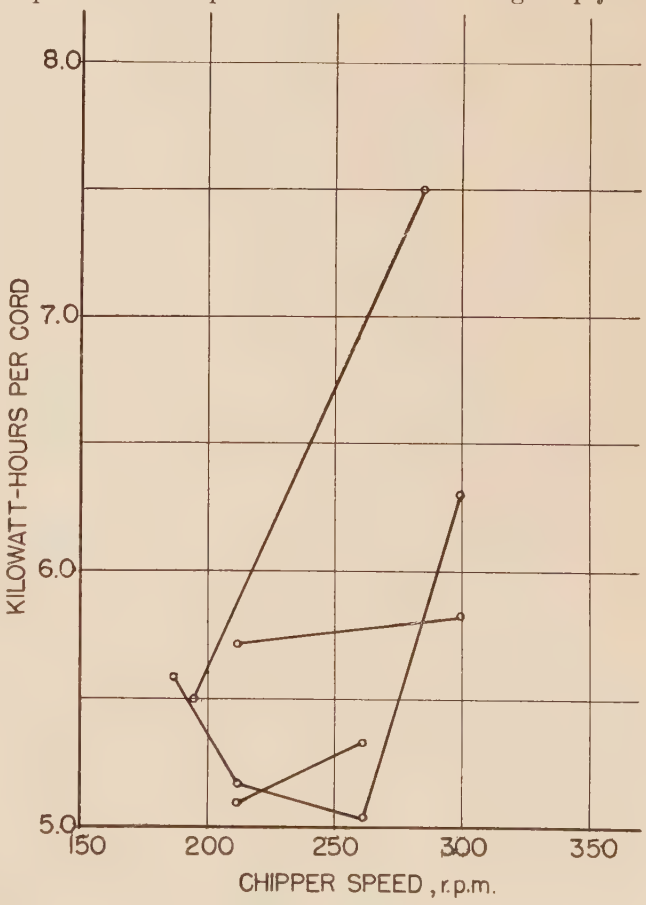

Fig. 2

as close as possible and never more than $^1/_{16}$-in. clearance. Recently two striking examples of bedplate neglect were seen, one on the East Coast and the other on the far West. The bedplate in the first instance had not been changed in 5 months—and showed it both in appearance and chip quality—while the second had not been changed in a year.

In order to insure the continuous production of good chips, routine daily figures should be compiled on power, chip quality, and total sawdust, and a running plot made of the results in order to detect trends. Records should be kept of knife life in cords or hours. Sawdust removed by the screens can be determined easily by a home-made dumping bucket or a satisfactory device can be purchased from manufacturers of threshing machinery. The woodroom foreman should be provided

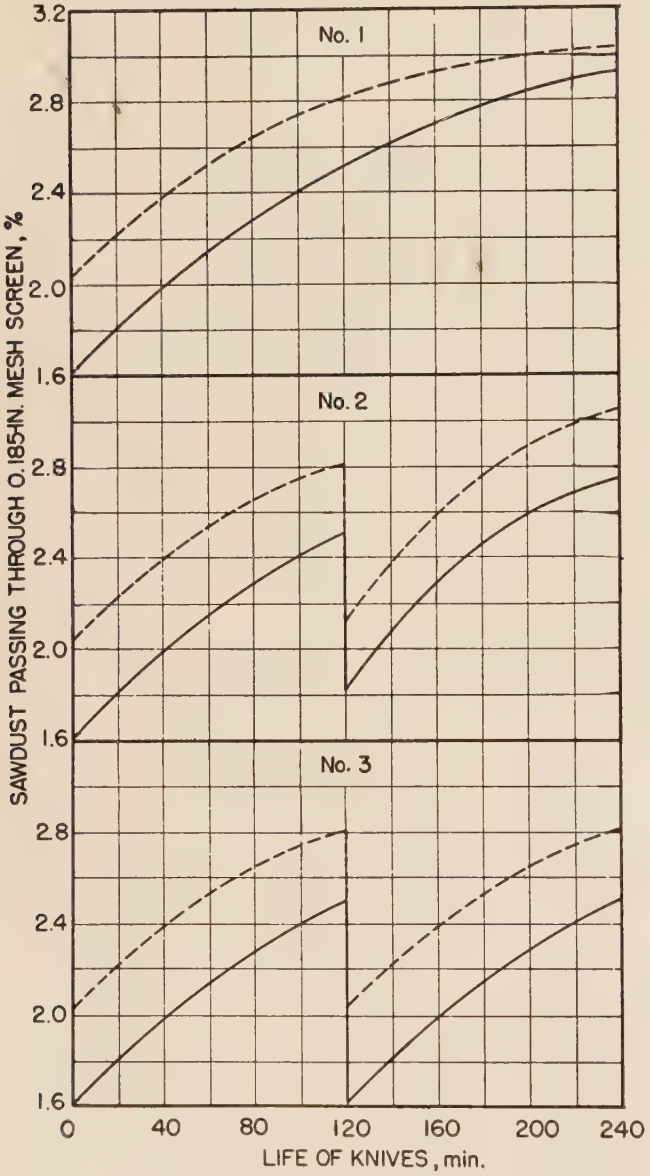

Fig. 3. Average curves showing production of sawdust under various operating conditions

—208 r.p.m. chipper. — 250 r.p.m. chipper.

Results from Fig. 4, using results obtained by the per cent of sawdust passing through 0.185-in. mesh screen.

88-in. (four-knife) chippers.

No. 1: Running knives 4 hr. without changing or filing.

No. 2: Running knives 4 hr. and filing at end of 2 hr. Time lost filing, approximately 6 min. per chipper.

No. 3: Running knives 2 hr. and changing. Time lost changing, approximately 12 min. per chipper.

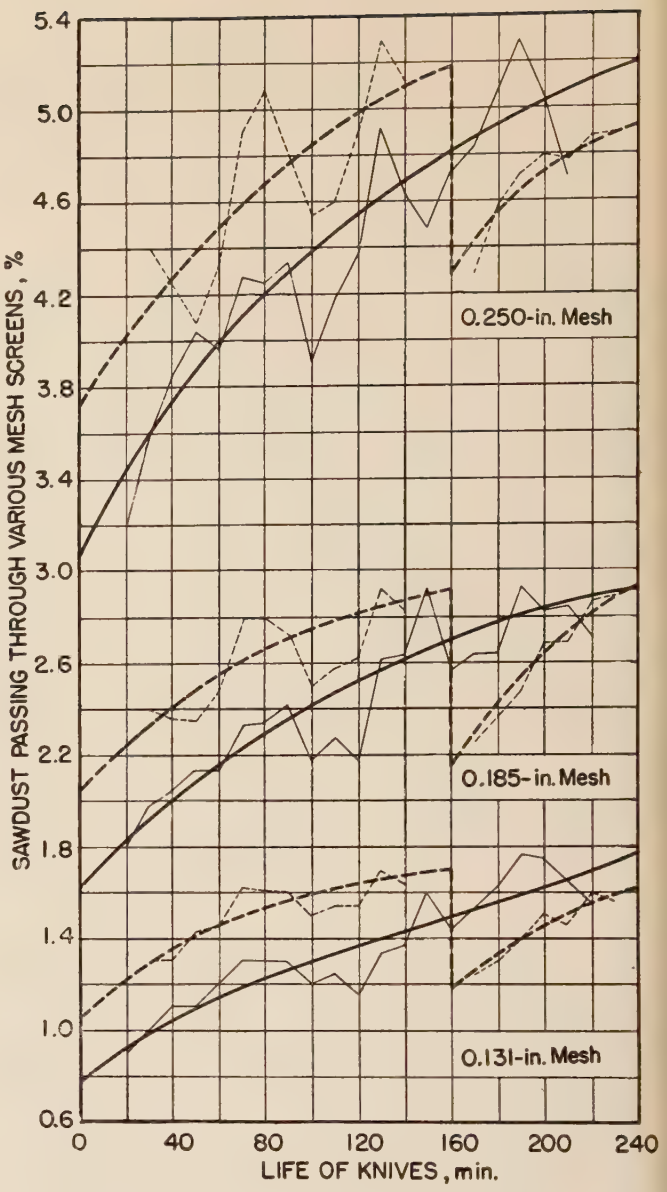

Fig. 4. Average curves showing life of knives at: slow speed, 208 r.p.m. versus fast speed, 250 r.p.m.

208 r.p.m.—weighted average. 208 r.p.m.—accepted values 250 r.p.m.—weighted average. 250 r.p.m.—accepted values.

Chippers: 88-in. (four-knife) chippers. Knife angle, 42°. Knives set for, $^3/_4$-in. chips. Babbitt bearings. 208 r.p.m. under load. 250 r.p.m. under load.

Wood: approximately 25% of test was run on pure jack pine, the other 75% was run on spruce and fir. Spruce, 60%; fir, 40%. Age of wood in yard from 2 to 3 years. Quality fair, small per cent cull. Moisture, 37%. Not frozen. Not redrummed.

Test and screens: chips taken directly from chippers under load, no cull. 0.250-in. mesh screen 36 by 60 in. Mounted on horse with roller, shaken 25 times. 0.185 and 0.131-in. mesh screen and pan mounted on rocker, shaken 30 times. Amount of chips samples: 2537 lb.; 136 samples; 18.7 lb. per sample.

with a small motor-driven nest of screens and scale so he can determine, independently and before the laboratory, just how the chips are running and how any change affects quality.

While it is going to be impossible, in most cases, to prove by wood consumption figures any savings resulting from better chipper operation, evidence has been presented to show that the savings and improvements are there, provided operation and maintenance are kept on a high level.

Received Sept. 6, 1951.

Surface Chemical Studies of the Conditions of Rosin Sizing

PER EKWALL and HENRIK H. BRUUN

In work conducted in collaboration with Oy Keskuslaboratorio-Centrallaboratorium Ab (The Research Institute of Finnish Pulp and Paper Industries), aluminium Helsingfors, the conditions for the reaction between aluminium ions and rosin acid, and the adsorption of aluminium ions and the adhesion of rosin acids and aluminium rosinates by cellulose fibers has been investigated. The factors influencing the reaction between aluminium ions and rosin acid monolayers have been defined by surface balance studies. The inception and completion of the reaction occur at well-defined pH values and aluminium ion concentrations. When the reaction has gone to completion the rosin acid in the monolayer has been transformed into a dibasic aluminium monorosinate. At higher pH values and aluminium concentrations precipitation of aluminium hydroxide occurs and it becomes difficult to define the conditions satisfactorily. With the aid of contact angle measurements it has been established that the reaction between solid rosin acid and aluminium ions in solutions takes place under the same conditions as when the rosin acid forms a monolayer on the surface of the solution. Only the surface layer of the solid rosin acid takes part in the reaction. The possibility of transferring a monolayer of rosin acid or of aluminium rosinate on cellophane and on unsized paper has been investigated. The changes in the wetting of the cellulose surface have been studied by contact angle measurements. The same factors which determine the reaction between rosin acid and aluminium ions have been found to be of importance in this process also. The ability of cellulose fibers to bind aluminium ions under different conditions has been measured using a surface balance technique specially developed for this purpose.

DESPITE the numerous investigations that have been carried out in the field of rosin sizing of paper, the actual processes involved have not been satisfactorily elucidated. This is evidently due to the fact that we are here concerned with a very complicated polyphase system. The process is accompanied by wide variations in acidity which effect many radical changes in the system. New interfaces appear and disappear; not only are the surfaces of the cellulose fibers involved, but also the surfaces of suspended particles of rosin acid, aluminium rosinates, and aluminium hydroxide. For this reason it was believed to be worth while to subdivide the problem into several simpler ones which could be attached separately with surface chemical methods. The experiments were conducted with tall oil rosin acid purified several times by crystallization (*1, 2*). In these investigations the authors have been assisted by Pentti Lahtonen and Reino Ekholm. Some of the results of this work have later been confirmed by similar studies carried out with purified individual rosin acids (*3, 4*).

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The first problem was to determine those conditions under which a reaction between free rosin acid molecules and aluminium ions is possible in general and to determine whether well-defined reaction products are formed and if such is the case, what are their compositions and their conditions of formation. In order to be able to study the reaction under as simple conditions as possible, the rosin acid was spread in a monomolecular layer on the surface of an aqueous solution containing aluminium ions and the influence of these ions on the properties of the monolayer was then studied with the aid of an automatic self-recording surface balance (*5*). This method of investigation proved to be very sensitive. The occurrence of a reaction became evident from changes in the shapes of the recorded pressure-area curves and it was possible to follow in this manner the transformation of the rosin acid in the monolayer into aluminium rosinate. These studies (*6–9*) established that under certain conditions the reaction leads to the formation of a reaction product with characteristic properties. The results of the surface balance studies can be summarized in two diagrams which show the dependence of the reaction on the aluminium ion and hydrogen ion concentrations (Figs. 1A and 1B).

The curves in Fig. 1A show the conditions for the reaction between aluminium ions and the rosin acid monolayer. The ordinate gives the negative logarithm of the total aluminium ion concentration and the abscissa the pH of the solution. Curve 1 shows the conditions where the reaction begins; to the left of this curve, no reaction occurs; to the right of the curve, the reaction attains wider scope, i.e., a larger proportion of the rosin acid in the monolayer is transformed into aluminium rosinate. In the conditions given by curve 2, the reaction has attained a certain end point. At the pH values and aluminium concentrations of curve 3, the solution becomes saturated with aluminium hydroxide and it becomes more difficult to obtain a reliable picture of the state of the system. Figure 1B shows the conditions for the same reaction when 2 mols sodium chloride per liter were added to the substrate. For the present the studies have been limited to the stable systems prevailing to the left of curve 3.

By an analysis of the monolayer substance it was established that under the conditions represented by curve 2, the rosin acid in the monolayer has been completely transformed into a dibasic aluminium monorosinate, which thus under these conditions is the final product of the primary reaction between rosin acid in the monoalyer and aluminium ions.

The conditions for the reaction between aqueous aluminium salt solutions and solid acid have also been studied. A layer of solid rosin acid on a glass slide was immersed in the solution. Changes undergone by the

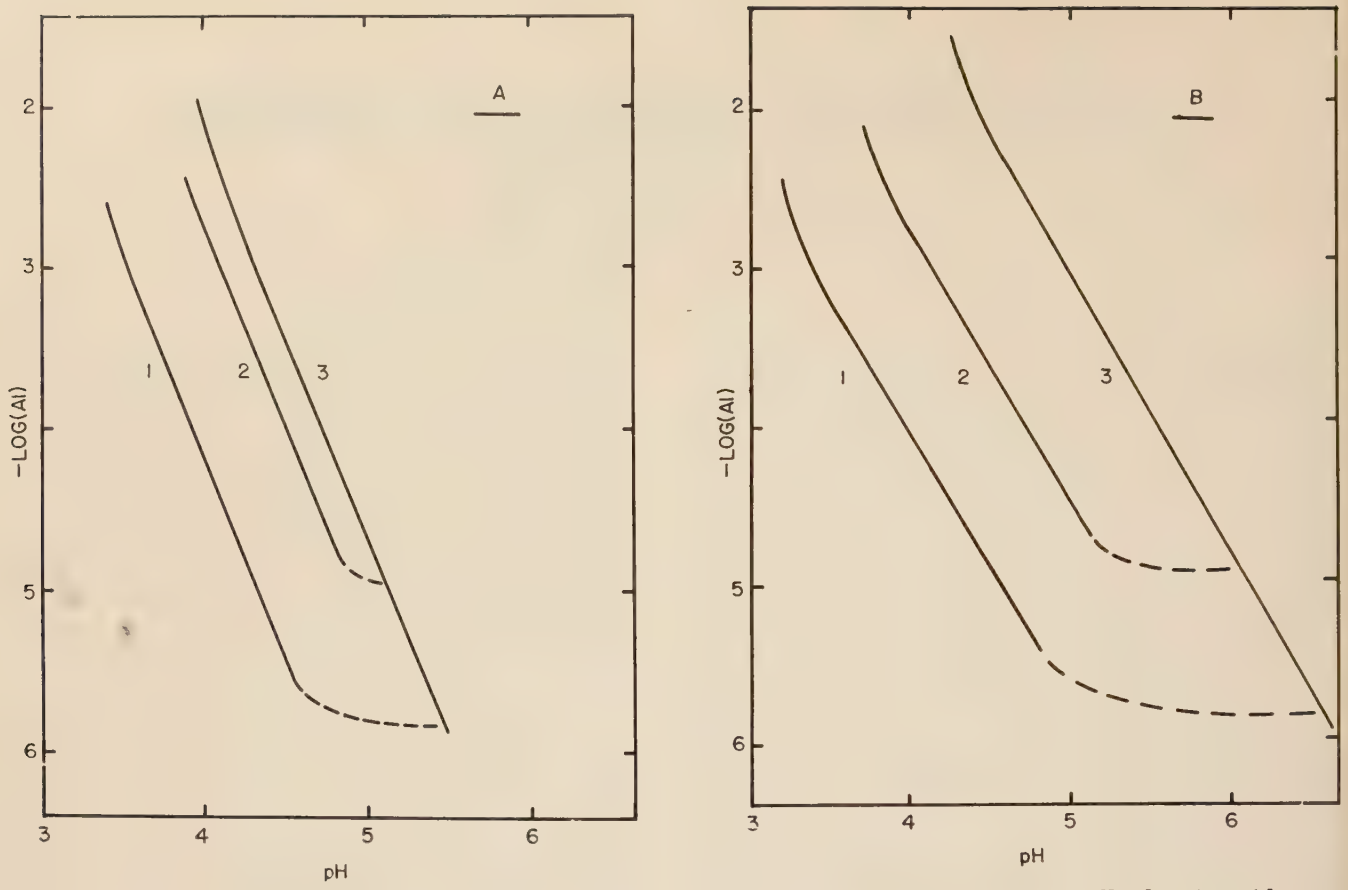

Fig. 1A and 1B. Schematic diagram showing the conditions in which reaction occurs between tall oil rosin acid monolayers and aluminium ions in an aqueous solution of $KAl(SO_4)_2$

Curve 1 gives the aluminium concentration (mols per liter) and pH values of the substrate when the first signs of reaction between aluminium ions and the rosin acid are noted. Curve 2 connects the aluminium concentrations and pH values at which maximum interaction is observed. Curve 3 gives the aluminium concentrations at which aluminium hydroxide precipitates in equilibrium conditions.

A. The $KAl(SO_4)_2$-solution contains no sodium chloride.

B. The $KAl(SO_4)_2$-solution contains 2 mols sodium chloride per liter.

(Ekwall and Bruun)

properties of the rosin acid were followed by performing contact angle measurements (using the drop method) (Fig. 2). The inception of reaction between aluminium ions and rosin acid was indicated by the observation that the contact angle of the pure water drop on the surface of the solid rosin acid began to increase and the end point of the reaction was indicated by the attainment of a constant high (or maximum) contact angle. The diagram in Fig. 3 shows the conditions where reaction between aluminium ions and solid rosin acid takes place. This diagram, which is similar to those in Fig. 1, shows that the conditions where the reaction begins and where it attains a well-defined end point are the same as when the rosin acid was spread in a monomolecular layer on a liquid substrate. The authors are of the opinion that the final product of the primary reaction formed under the conditions represented by curve 2 is also in this case a dibasic aluminium monorosinate. It has been established that the reaction is limited to the surface layer of solid rosin acid and does not continue deeper into the solid acid layer.

The contact angle measurements also illustrate the water-repellent properties of different rosin materials and show that aluminium monorosinate is more water-repellent than the unreacted rosin acid and surface layers containing rosin acid and aluminium in proportions that correspond to aluminium tri- and dirosinates.

The pronounced water-repellent properties of aluminium monorosinate become more clearly evident when hydrophilic solid surfaces covered with a monomolecular layer of rosin acid or different aluminium rosinates are studied. The effect of such monolayers on the hydrophilic properties of glass (*7*, *8*, *10*) and cellulosic materials (*10*) has been investigated and also the conditions under which monolayers become attached to these surfaces. The layers were transferred to the solid surfaces from the surface of aqueous solutions of different pH and different aluminium ion concentrations by the built-up technique. The variations in the hydrophilic properties were evaluated by contact angle measurements.

A monolayer of pure rosin acid does not adhere to a clean glass or cellophane surface (Fig. 4, A and B). However, when the monolayer contains a little aluminium, adhesion to the solid surface occurs. The hydrophobic properties of the covered surface increase as the composition of the monolayer approaches that of aluminium monorosinate. A single monomolecular layer of dibasic aluminium monorosinate is able to increase the contact angle of water on glass from 0 to 100° and on cellophane from about 35 to 100°.

It was also found possible to transfer (*10*) a monolayer of dibasic aluminium monorosinate to the surface of unsized paper (hard filter paper, W. & R. Balston Ltd., genuine Whatman filter paper no. 50; the aluminium ion concentration of the solution was 10^{-5} *M* and the pH was 5.0). The total area of the fibers in this paper was estimated to be about 200 times the macro-

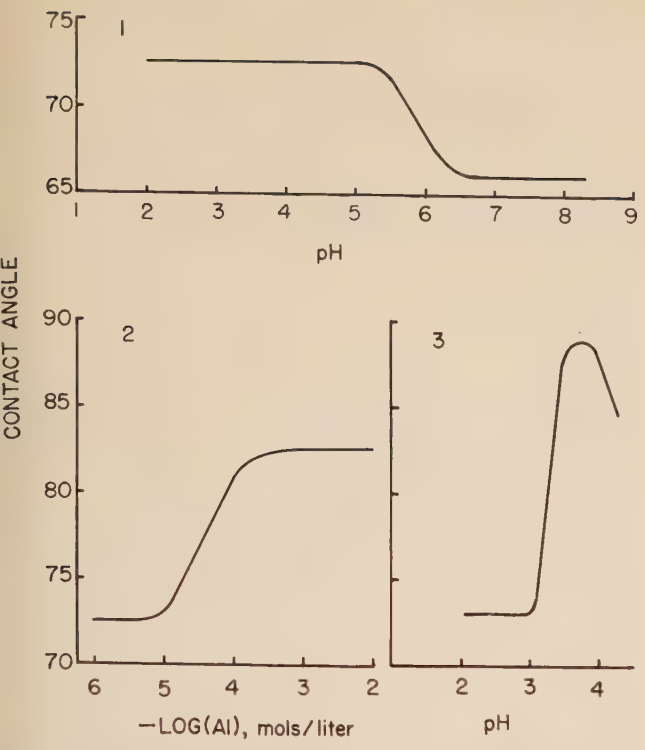

Fig. 2. Contact angles between pure water and the surface of a solid rosin acid layer which has been immersed in aqueous solutions of different pH and aluminium ($KAl(SO_4)_2$) concentrations

Curve 1: variation of contact angle when the pH of water containing no dissolved aluminium) is varied. Curve 2: variation of contact angle when the pH of the aqueous solution is held constant at 4.30 and the aluminium concentration is varied. Curve 3: variation of contact angle when the aqueous solution contains 0.01 mol aluminium per liter and the pH is varied.

The contact angles have been measured by the drop method drop on the horizontal solid surface).

(Ekwall, Bruun, Lahtonen)

scopic area of the paper surface. In order to obtain an increase in the contact angle from 0 to 100°, only one quarter of the aluminium rosinate necessary to cover the whole of the fiber area with a monomolecular layer was required (Fig. 5). The reason for this is probably that the rosinate does not spread completely around over the fibers but is concentrated on the outer surface of the paper.

The studies thus prove that the presence of aluminium rosinate in a rosin acid monolayer promotes the adhesion of the monolayer to cellulosic surfaces. In order to throw some light on the actual mechanism by which aluminium rosinate becomes attached to the fiber surface, the ability of cellulose to bind aluminium ions was studied. To date, experiments have been performed with four different cellulosic materials (one cotton cellulose and three types of sulphite cellulose), in which the total number of acid groups determined by the method of Wilson (*11*) was found to vary from 0.8 to 5.4 milliequivalents per 100 grams of cellulose. The uptake of aluminium was determined by a special surface balance technique (*9*). The results are shown in Fig. 6. In the range studied the amount of aluminium taken up by the cellulose is independent of the total aluminium ion concentration, but varies with the pH. The amount of bound aluminium increases linearly with the pH up to pH 5, at which aluminium hydroxide is formed which adheres to the fibers. The aluminium uptake is greater (the slope of the curve increases) the higher the number of acid groups in the cellulose. All the curves intersect the abscissa axis at pH 3.4 to 3.5. At lower pH values, the different cellulose types studied bind practically no aluminium ions (less than one millionth of a millimol of aluminium per 100 grams). If it is true that the result of the rosin sizing depends on the reaction of aluminium with the acid groups present in the cellulose, it follows from this study that the pH of the solution used in the case of investigated types of cellulose should not be less than 3.5.

When the pH attains approximately the value 5 and aluminium hydroxide begins to precipitate, only about 40% of the acid groups have reacted with the aluminium ions. In order to utilize the binding power of the cellulose for aluminium ions completely it would be necessary to raise the pH to a value of about 7, but at this pH aluminium hydroxide is precipitated and the formation of a well-defined aluminium monorosinate seems to be more difficult. This pH is outside the range of conditions in which the studies have been conducted for the present.

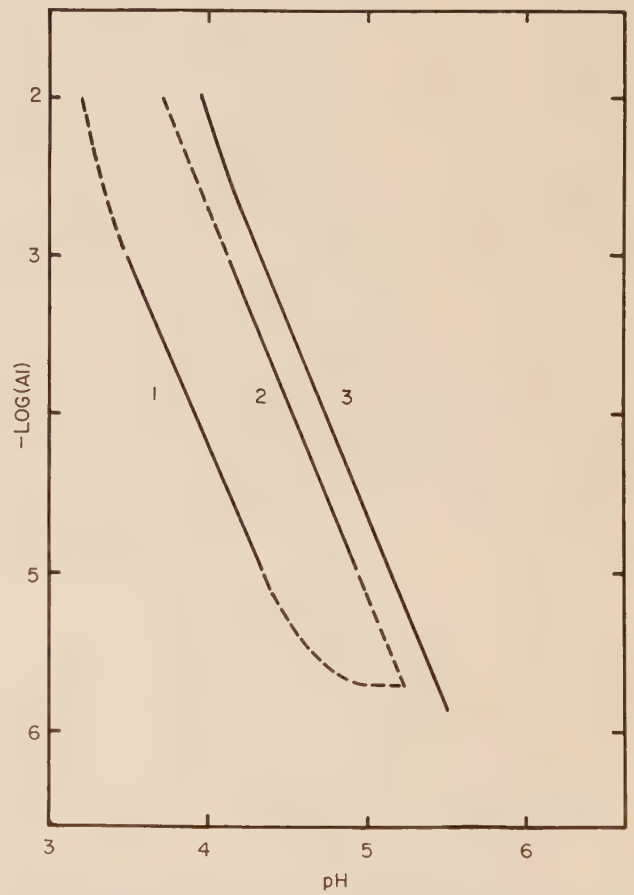

Fig. 3. Diagram showing the conditions in which reaction takes place between aluminium ions in an aqueous solution of $KAl(SO_4)_2$ and the surface of solid rosin acid immersed in the solution. The reaction has been studied by means of contact angle measurements

Curve 1 gives the aluminium concentrations and pH values at which the first signs of reaction between aluminium ions and the solid rosin acid surface are noted; curve 2 gives the aluminium concentrations and pH values at which the maximum effect of aluminium ions is observed; curve 3 gives the aluminium concentrations and pH values where aluminium hydroxide is precipitated.

(Ekwall, Bruun, Lahtonen)

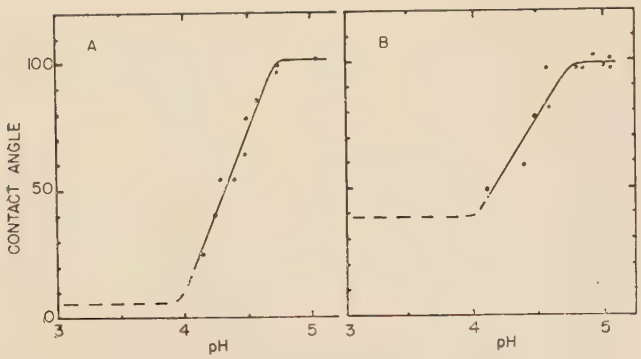

Fig. 4A and 4B. The water-repellent properties of glass and cellophane surfaces covered with monomolecular layers of rosin acid-aluminium monorosinate mixtures (built-up technique)

A, glass; B, cellophane. Ordinate: contact angle between a pure water drop supported on the covered glass and cellophane surfaces. Abscissa: the pH of the substrate, from which the monolayer was taken up. The aluminium ion concentration of the substrate was 10^{-5} *M*.
(Ekwall and Ekholm)

The studies appear to show that if one wishes to carry out rosin sizing with a well-defined aluminium rosinate, the conditions are limited in the direction of low pH values by two factors: the conditions which permit the formation of aluminium rosinate and the conditions determining the power of cellulose to bind aluminium ions. In the direction of higher pH values, the range is limited by the conditions at which aluminium hydroxide formation possibly alters the conditions favoring the formation of a well-defined aluminium rosinate and by those at which the ability of the cellulose to bind aluminium attains its maximum. The dibasic aluminium monorosinate possesses better water-repellent properties than the di- or trirosinates, and, as far as is known at present, probably also better properties than the rosinate formed in the reaction between aluminium hydroxide and rosin acid. It is now intended to investigate more thoroughly the products of the latter reaction and to study if their apparently weaker water-repellent properties are compensated by a better adhesion to the cellulose fibers.

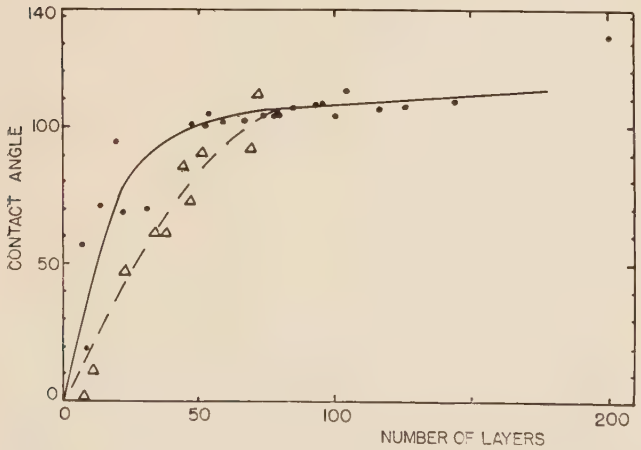

Fig. 5. Variation of the water-repellent properties of filter paper covered by different amounts of aluminium monorosinate (built-up technique)

The ordinate denotes the contact angle between pure water and the covered filter paper. The unit of the abscissa is the amount of rosinate required to cover the macroscopic area of the paper with a layer 1 molecule thick. The dots and triangles refer to two different experimental series.
(Ekwall and Ekholm)

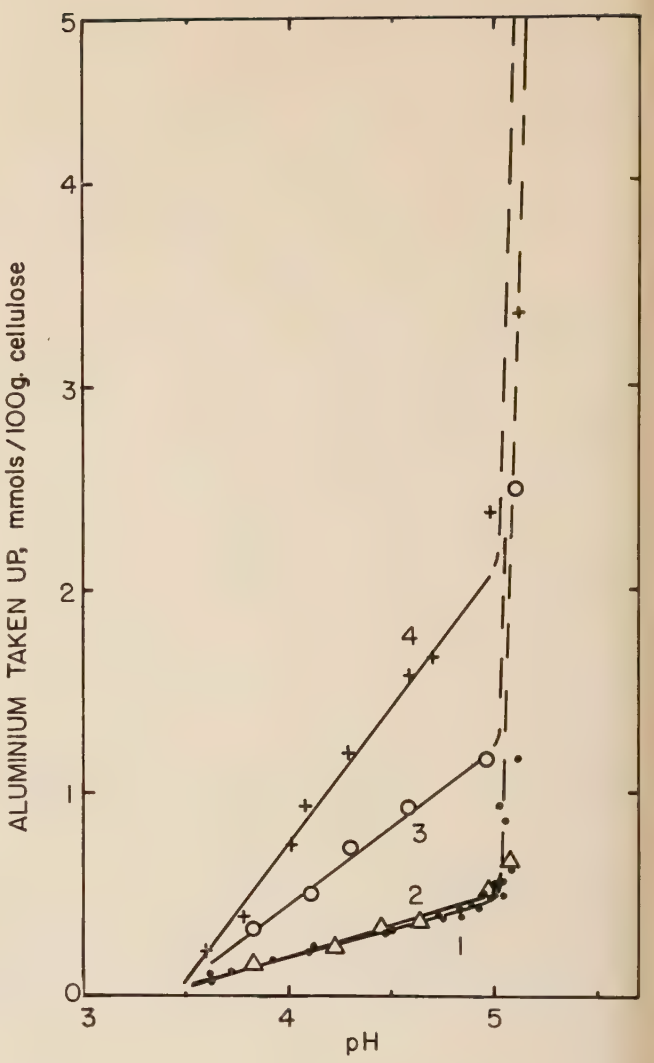

Fig. 6. The uptake of aluminium from $KAl(SO_4)_2$-solutions by cellulosic materials at different pH values, 20°C.

1. Filter paper (Munktell no. 00). Acid groups: 0.8 milliequivalent/100 g. cellulose
2. Bleached sulphite cellulose. Acid groups: 0.9 milliequivalent/100 g. cellulose
3. Bleached sulphite cellulose. Acid groups: 2.6 milliequivalent/100 g. cellulose
4. Bleached sulphite cellulose. Acid groups: 5.5 milliequivalents/100 g. cellulose

(Ekwall and Bruun)

LITERATURE CITED

1. Aschan, O., "Naphtenverbindungen, Terpene und Campherarten," pages 288, Berlin and Leipzig, 1929.
2. Harva, O., Dissertation, *Acta Acad. Aboensis, Math. Physic.* 17, No. 4: 13 (1951).
3. Bruun, H., Paper read at the VIII Nordiska Kemistmötet, Oslo, 1953, and at the XIIIth International Congress of Pure and Applied Chemistry, Stockholm and Uppsala, 1953.
4. Bruun, H., Dissertation, *Acta Acad. Aboensis, Math. Physic.* 19, No. 3 (1954).
5. Andersson-Groth, K. J. I., Ställberg-Stenhagen, S., and Stenhagen, E., in *The Svedberg, 1884, 30/8, 1944,* Uppsala (1944), page 11.
6. Ekwall, P., and Bruun, H., *Paper & Timber B* 32: 194 (1950).
7. Ekwall, P., *Svensk Kem. Tid.* 63: 277 (1951).
8. Ekwall, P., *Kolloid Z.* 125: 129 (1951).
9. Ekwall, P., and Bruun, H., unpublished data.
10. Ekwall, P., and co-workers, Unpublished data.
11. Wilson, K., *Svensk Papperstidn.* 51: 45 (1948).

Received March 29, 1954. Lecture held at the VIII Nordiska Kemistmötet, Oslo, 1953, and at the XIIIth International Congress of Pure and Applied Chemistry, Stockholm and Uppsala, 1953.

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The Design and Effectiveness of an Underwater Diffusion Line for the Disposal of Spent Sulphite Liquor

H. R. AMBERG and A. G. STRANG

A problem associated with the discharge of spent sulphite liquor into the Columbia River has been excessive bacterial slime growth. These filamentous growths of *Sphaerotilus*, which are dependent upon the sugar fraction in the waste, were of particular nuisance near the Vancouver area since the sloughed growths would collect and become attached to the gill nets of the commercial fishermen, making commercial fishing operations extremely difficult during certain periods of the year. Previous studies indicated that no significant growth would develop at spent sulphite liquor concentrations below 50 p.p.m. of 10% liquor. Since sufficient dilution water was available in the Columbia, it was decided that underwater diffusion lines would be effective in diluting the liquor below the minimal concentration required for excessive slime growth. This paper presents a description of the underwater diffusion line installed at the Columbia River Paper Mills at Vancouver, Wash., as well as survey data used to arrive at a rational design of the underwater outfall. Comprehensive stream surveys were conducted before and after the installation of the underwater outfall to ascertain the degree of improvement effected by the outfall. Since the underwater diffusion line has been installed, the waste concentration in critical areas along the shoreline has been reduced by 95% and concentrations of spent liquor are considered sufficiently low to prevent excessive slime growth.

Excessive slime growths in the Columbia River have been a problem associated with the discharge of spent sulphite liquor for a number of years. Lincoln and Foster (*1*) conducted a comprehensive survey on the lower Columbia River in 1943 and they concluded that spent sulphite liquor discharged by the pulp mills channeled along the shoreline for considerable distances before being adequately diluted with river water. They found that the high concentrations of spent sulphite liquor along the Washington shore were primarily responsible for slime growth since *Sphaerotilus*, the filamentous bacteria involved, is dependent upon the sugar fraction of the waste for its energy and carbon source. Experimental studies conducted at that time showed that concentrations of spent sulphite liquor below 50 p.p.m. were insufficient to stimulate excessive growths.

Based upon these studies, the sulphite mill at Camas, Wash., constructed an underwater disposal line with diffusion headers which discharged into the main stem of the Columbia River (*2*). This line has been very effective in insuring proper dilution of the spent sulphite liquor below the minimum required for excessive slime growth.

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During January and February of 1953 numerous complaints were received from commercial fishermen fishing in the vicinity of Vancouver with particular emphasis on the "sliming" of gill nets. The slime was found to be a species of *Sphaerotilus*. It was decided that an underwater diffusion line at the Columbia River Paper Mills would be an effective method of diluting the spent sulphite liquor discharged by this mill below the minimal requirements of *Sphaerotilus*.

A comprehensive survey of the Columbia River in the vicinity of Vancouver, conducted by the National Council for Stream Improvement and the Columbia River Paper Mills' personnel, was started on March 4, 1953, and continued through March 19. The purpose of this initial survey was to determine the spent sulphite liquor distribution pattern from the Interstate Bridge to a point 9 miles below the outfall of the Columbia River Paper Mills. The data collected during this initial survey would serve as a base line for comparison with any future improvements that might be made and would afford information on pollution from upstream sources.

Current studies were also conducted in the vicinity of the proposed pulp mill outfall to determine the quantity of dilution water available and to arrive at a rational design for an underwater diffusion line.

On September 11, 1953, the underwater diffusion line was put into operation and another comprehensive sampling program was initiated on September 23 through October 20 to ascertain the degree of improvement effected by the installation of the underwater diffusion line.

SOURCES OF POLLUTION

The main sources of domestic and industrial pollution along the stretch of river from Camas through Vancouver are the liquid wastes from the sulphite mill at Camas, the sulphite wastes from the Columbia River Paper Mills, and sewage from Camas and Vancouver.

A municipal sewer system serving approximately 3000 persons in Camas discharges untreated sewage into Camas Slough. Immediately east of Vancouver about 4000 persons are served by sewers that drain the McLoughlin Heights Addition and surrounding areas to the Columbia River at three different outfalls. About 30,000 people in Vancouver are served by sewers—the sewage receiving primary treatment prior to its discharge west of the Vancouver Railroad Bridge. A few hundred feet east of the Interstate Bridge a sewer which drains from the Veterans Administration Hospital and other buildings, discharges at the bank of the river—the liquid waste from an estimated population of 2000. Plans are under way to treat this waste at the Vancouver sewage treatment plant.

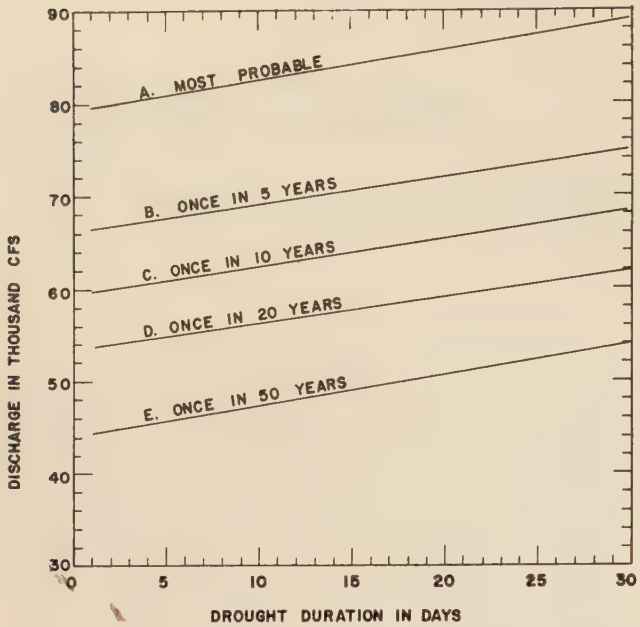

Fig. 1. Relation between severity and duration of Columbia River drought flow based upon probability studies of The Dalles' gage record

The Portland sewer outfall is located a short distance west of the Railroad Bridge on the Oregon side of the river. At the present time only about 40% of Portland sewage is being treated and discharged to the Columbia River. However, in the near future the entire volume of Portland sewage, after primary treatment, will be discharged to the Columbia River.

The main source of pollution from the Camas pulp mill is the spent sulphite liquor from the rated production of 400 tons of sulphite pulp per day. At the present time the sulphite liquor is being discharged into the main stem of the Columbia River by means of an underwater diffusion line. The use of this line has resulted in improved river conditions, and mixing of waste with dilution water is so complete that a pollution problem with regard to excessive *Sphaerotilus* growth no longer exists below this mill.

The main source of pollution from the Columbia River Paper Mills was the spent sulphite liquor from the production of about 100 tons of sulphite pulp per day. Prior to the installation of the underwater diffusion line the waste was discharged along the shore, and channeling of the waste along the Washington shore for more than 8 miles below the outfall was not uncommon. After installation of the underwater diffusion line at the Columbia River Paper Mills, the spent sulphite liquor, plus a portion of the wash water, was discharged through the line. White water from the paper machines, bleach liquor, and other miscellaneous wastes were discharged from the old sewer, but these wastes did not constitute a pollution problem because of their low sugar content.

The sewage discharged along the Washington shore in the distance under consideration is approximated at 3 m.g.d. Although this volume is insufficient to cause a serious pollution problem, the discharge of sewage in conjunction with spent sulphite liquor may stimulate the excessive growths of *Sphaerotilus*.

HYDROLOGY

Records of continuous discharge of the Columbia drainage system are available in the U. S. Geological Survey water supply papers for gaging stations on the main stem and on major tributaries. The Dalles' gage is most important because it is the last downstream measurement of discharge on the main stem. Discharge along the lower miles of the Columbia below The Dalles may be developed from The Dalles' record and estimates of increments from the tributaries. Below The Dalles at Bonneville, discharge is subject to some minor fluctuations from power plant operations at Bonneville, and complications of tide necessitate accurate measurement of flow through the stretch of river under consideration.

Table I. Probability of Minimum Monthly Average Discharge by Months of the Year Based on The Dalles' Record

Month	*Most probable discharge, c.f.s.*	*Once in 5 yrs., c.f.s.*	*Once in 10 yrs., c.f.s.*	*Once in 20 yrs., c.f.s.*
January	104,000	92,000	85,000	80,000
February	108,000	96,000	89,000	84,000
March	128,000	106,000	94,000	85,000
April	190,000	144,000	120,000	100,000
May	348,000	270,000	228,000	195,000
June	410,000	323,000	278,000	240,000
July	260,000	203,000	172,000	148,000
August	153,000	127,000	114,000	103,000
September	106,000	96,000	91,000	86,000
October	92,000	82,000	76,000	72,000
November	90,000	85,000	82,000	80,000
December	89,000	80,000	76,000	72,000

The seasonal pattern of discharge of the Columbia is quite definite, with a marked dry weather period during the Fall–Winter period and high runoff during the Spring-Summer season. A probability study of the monthly mean discharge for each month of the year, based upon The Dalles' gage record, has been made from which characteristics of variation of individual months of the year have been defined and from which a general pattern emerges. Results of these studies are given in Table I showing the most probable monthly

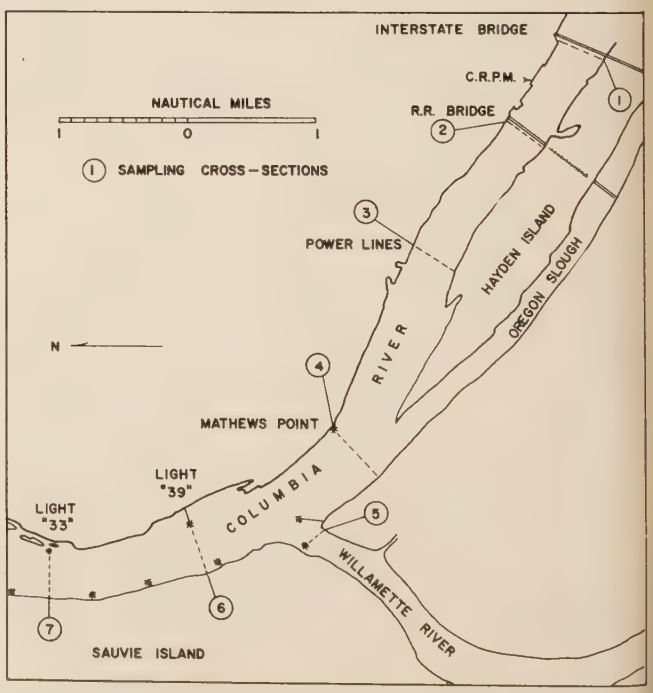

Fig. 2. The Columbia River in the vicinity of the Columbia River Paper Mills (C.R.P.M.) showing sampling cross sections

mean discharge expected and droughts expected on the average in the long run once in 5 years, once in 10 years, and once in 20 years. Taking a discharge of 100,000 c.f.s. at The Dalles, most probably the monthly mean discharge of January, February, March, September, October, November, and December will be below 100,000 c.f.s.; and once in 10 years it can be expected that the monthly mean discharge of January, February, March, September, October, November, and December will be below 100,000 c.f.s.

Probability studies based on The Dalles' record indicated that cumulative number of days' (not necessarily consecutive) flow less than 90,000 and 100,000 c.f.s. can be expected on the average in the long run, as shown in Table II. It is apparent that, on the average in the long run, every other year 103 days' flow less than 100,000 c.f.s. can be expected, and once in 10 years 212 days can be expected below 100,000 c.f.s.

Table II. Expected Cumulative Number of Days' Discharge at the Dalles Will Be Less Than 90,000 and 100,000 C.f.s.

Probability	*Number of days' discharge less than 90,000 c.f.s.*	*Number of days' discharge less than 100,000 c.f.s.*
Most probable number	62	103
Once in 5 yr.	128	175
Once in 10 yr.	161	212
Once in 20 yr.	190	252

In the design of a pollution abatement program the severity of drought which can be expected at various probabilities during the drought season becomes important in ascertaining the allowable pollution load to maintain a desired stream condition. Employing the theory of extreme values (*3*), detailed analyses have been made of the record at The Dalles' gage, the results of which are shown in Fig. 1. It is evident from this illustration that as the period over which the discharge is averaged is shortened, the drought severity increases. From the detailed probability studies the relationship between severity and duration of drought has been developed (as illustrated in Fig. 1), from which drought flows expected at The Dalles' gage at any time during the Fall-Winter period (September through March) as

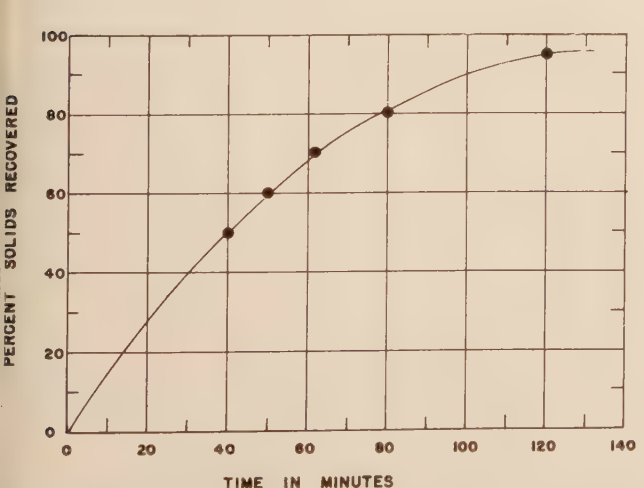

Fig. 3. Relationship between solids recovery from blow pits and collection time

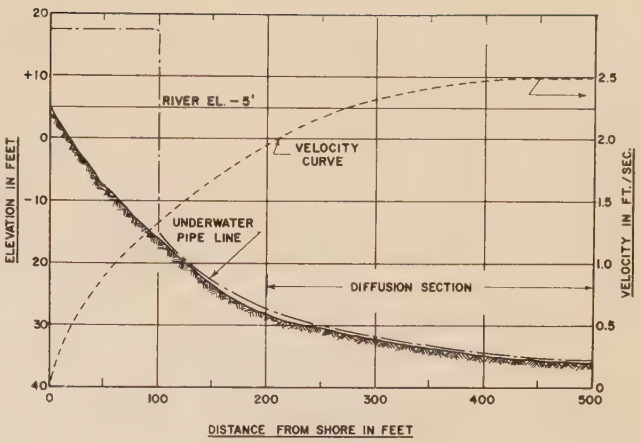

Fig. 4. Columbia River velocity curve and river profile in front of the Columbia River Paper Mills, showing the underwater diffusion line

an average discharge over any number of consecutive days from 1 to 30 days' duration can be obtained readily.

SAMPLING PROCEDURE

Eight cross sections were established at intervals along the Columbia River from the Interstate Bridge to Reeder Point Light, about 8.8 miles below the Interstate Bridge (Fig. 2). Each section had three to eight sampling points or stations at which samples were collected. Samples were taken at these sections at hourly intervals for 8 hr. per day to determine the variability of spent sulphite liquor concentration throughout an 8-hr. cycle. Since the pulping process is essentially a batch process, considerable fluctuation throughout a 24-hr., or even an 8-hr. period, would be expected.

The cross sections, their location, and the date sampled are given in Table III.

Because the primary problem was one of exceeding the 50 p.p.m. spent sulphite liquor requirement, the only data taken were temperature and spent sulphite liquor concentration. Spent sulphite liquor concentrations were determined by using a Fisher electrophotometer with a 50-mm. cell, and after the installation of the the pipe line spent sulphite liquor concentrations were determined by using a Model 402 E Lumetron colorimeter with a 150-mm. cell. All concentrations reported were based on 10% ammonia-base liquor.

SURVEY RESULTS

Design of Underwater Diffusion Line

One phase of this survey was to conduct current studies of the river in the immediate vicinity of the mill and to determine the quantity of dilution water available for an underwater diffusion line.

One of the primary factors in the design of a treatment or abatement program entails a thorough study of the liquor collection system and the subsequent pattern of discharge. The sulphite mill of the Columbia River Paper Mills has four 12-ton and one 16-ton digester, and at normal production $2^1/_2$ hr. are involved between "blows." During the $2^1/_2$-hr. washing period the concentration of sulphite solids will vary with time. The relationship between solids recovery and collection time is graphically shown in Fig. 3. In 60 min. approximately 70% of the solids are removed from the pulp, and in 120 min. 95% of the solids are removed.

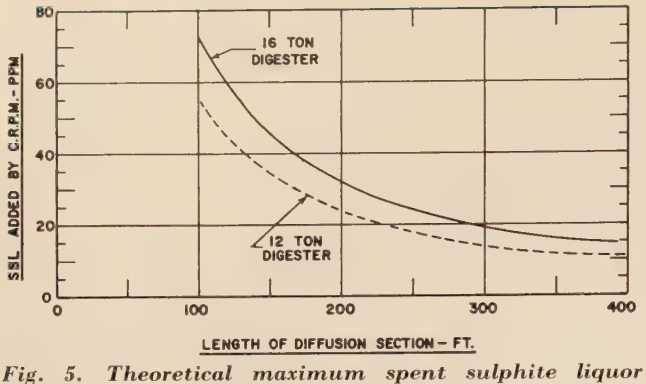

Fig. 5. Theoretical maximum spent sulphite liquor concentration added by the Columbia River Paper Mills as effected by diffusion length of underwater outfall

For practical purposes the amount of pollution discharged after $2^1/_2$ hr. of washing is negligible because 95% or more of the solids have been removed.

Table III. Sampling Cross Sections

Sampling section	Distance from Interstate Bridge Ft. × 10^3	Miles	Number of sampling station	Dates sampled
1. Interstate Bridge	0	0	7	3-11-53 9-23-53 10- 6-53
Columbia River Paper Mills	2.0	0.38	..	...
2. SP & S Railroad Bridge	4.6	0.87	7	9-23-53 3- 4-53 3-12-53 10- 6-53
3. Power lines	12.0	2.27	7	3-12-53 3- 4-53 9-25-53
4. 1000 ft. below Mathews Point	23.0	4.35	7	3-13-53 3- 9-53 3- 5-53 9-25-53
5. Mouth of Willamette	26.0	4.92	3	3-13-53 3- 9-53 3- 5-53 10- 2-53
6. Morgan Dike Light, no. 39 and no. 40	30.5	5.77	7	3-13-53 3- 9-53 3- 5-53 10- 2-53
7. Hewlitt Dike Light, no. 33	38.0	7.20	8	3-18-53 3- 9-53 3- 6-53 10- 2-53
8. Reeder Point Light no. 28	46.3	8.77	7	3-18-53 3- 6-53 10- 2-53

The distribution pattern of spent sulphite liquor above the proposed Columbia River Paper Mills' outfall shows that the mean spent sulphite liquor concentration coming to the mill is approximately 20 p.p.m. allowing about 30 p.p.m. additional spent sulphite liquor from the Columbia River Paper Mills.

Current measurements were made with a Stevens' current meter for approximately 450 ft. from shore in front of the Columbia River Paper Mills during the start of the ebb tide. A higher velocity would be expected during ebb tide and the current would be somewhat less during the other tidal cycles. The river discharge at The Dalles during this study was 130,000 sec.-ft., which was somewhat higher than the drought flow of 80,000 to 90,000 sec.-ft.

There were so many variables involved that at best the results of this study would serve primarily to show relationships and would be valuable as an approxima tion of diffusion length required. The velocity curv developed at various distances from the shoreline i presented in Fig. 4. It can be seen that the velocity di not reach its maximum until a distance of approximatel 450 ft. from shore was reached, and at a distance of les than 200 ft. from shore the velocity was less than 2 ft per sec.

A cross section developed for a distance of 500 ft. i front of the mill is also shown in Fig 4. Based upo the current studies, it was decided that the first 20 ft. of the waste line (from shore) would not be used fo diffusion.

Table IV summarizes the data from Fig. 4 and pre sents the water flow through each 50-ft. segment beyon the inner 200-ft. length at a river discharge of 135,00 c.f.s. at The Dalles.

Table IV. Summary of Current Studies and Dilutio Water Available for Dispersion of Spent Sulphite Liquo

Section	Mean velocity, ft./sec.	Mean depth, ft.	Width of segment, ft.	Area of segment, sq. ft.	Flow per segment, c.f.s.	Cumulative flow, c.f.s.
A	2.1	34.0	50	1700	3570	3,570
B	2.2	36.5	50	1825	4020	7,590
C	2.3	38.0	50	1900	4370	11,960
D	2.4	39.5	50	1975	4740	16,700
E	2.5	40.0	50	2000	5000	21,700
F	2.6	41.0	50	2050	5330	27,030

For a 200-ft. diffusion section, approximately 16,70 c.f.s. of dilution water will flow over the diffusio section, and for a 300-ft. diffusion section, abou 27,030 c.f.s. of dilution water will flow over the diffusio section. By discharging the entire wash water an liquor, with no allowance for equalization, approxi mately 70% of the solids will be discharged in 1 hr. or roughly 21,800 and 29,000 lb. of moisture-fre sulphite solids, respectively, for the 12 and 16-to digesters.

The theoretical calculated concentration of spen sulphite liquor added to the Columbia River by th Columbia River Paper Mills is plotted in Fig. 5 for th 12 and 16-ton digesters as a function of the diffusio length and assuming intimate and instantaneous mix ing of the spent liquor with the receiving stream. Fo a 300-ft. diffusion section, the concentration of spen

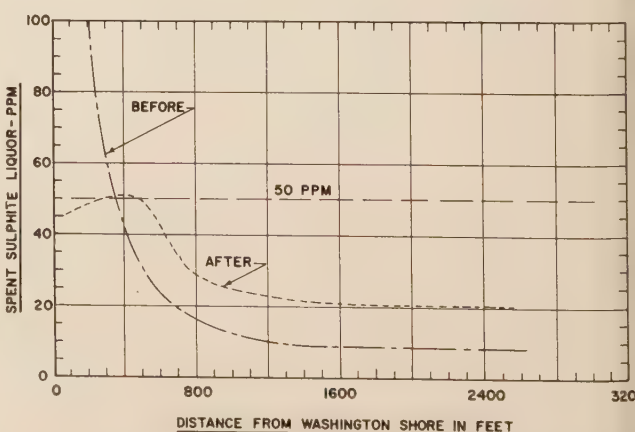

Fig. 6. Mean spent sulphite liquor concentrations befo and after the installation of the underwater diffusion lin 2600 ft. downstream from the outfall

Table V. Design Data for the 300-Ft. Section of the Underwater Diffusion Line

	Hole number from inshore end										
	1	2	3	4	5	6	7	8	9	10	11
Diameter of discharge orifice, in.	1 1/2	1 1/2	2	2	2	2	2	2	2	2	2
Discharge at 9-ft. head, g.p.m.	80	76	128	113	106	100	95	92	90	89	88
Approximate velocity of discharge, f.p.s.	14.9	14.1	12.4	10.8	10.1	9.6	9.1	8.8	8.6	7.6	7.5
Spacing between outlets, ft.	20	40	40	40	30	30	30	25	25	15	

liquor added will be 15 and 20 p.p.m. respectively, for the 12 and 16-ton digesters at a river discharge of 135,000 c.f.s. at The Dalles. The greatest reduction in spent sulphite liquor concentration occurred when increasing the 100-ft. diffusion section to 200 ft., and any increase in excess of 200 ft. brought about a smaller decrease in spent sulphite liquor concentration. A diffusion section in excess of 300 ft. was not recommended because the decrease in spent liquor concentration would be insufficient to warrant installation of a longer section.

Underwater Distribution Line

Based upon the current studies, it was decided to construct a distribution line extending into the main channel of the river. Because this is a navigational channel, the distribution line had to be constructed to facilitate removal of the line during dredging operations. The installation is unique because the distribution line can be removed and replaced in 8 hr.

The five blow pits have individual 8-in. valves connected to a header that feeds into a 1000-g.p.m. pump. The pump is connected to an 8-in. stainless steel line 650 ft. long, which leads to the river bank. At the river bank an 8-in. spiral wire embedded rubber hose runs overhead for 150 ft. to a dolphin, which guides a stainless steel section to the river bottom. A 6-in. marine-type spiral wire embedded rubber hose is connected to the stainless steel section and extends into the main channel for 400 ft. The first 100 ft. of underwater line have no diffusion outlets and the outer 300 ft. contain the distribution header. Outlets of 1 1/2 to 2 in. are spaced in the line for uniform distribution of the liquor. The orifice size, waste discharge, velocity of discharge, as well as the spacing between outlets, are tabulated in Table V.

The outlets are type 316 stainless steel spools drilled for the proper outlet size and connected to the steel flanges on the rubber pipe. The rubber line is strapped at 36-in. spacings to 28-lb. per ft. round link chain to prevent drift and to facilitate the raising and lowering of the line.

To raise the line a barge is floated over the line near the outer end and, by using a hook similar to a boat anchor, the line is raised to the barge, each length disconnected and placed on the barge. The rubber pipe lengths range from 25 to 40 ft. Replacing the line is handled in a similar manner, only in reverse. A marine diver is needed only to connect and disconnect the rubber line from the stainless steel line at the flange connection.

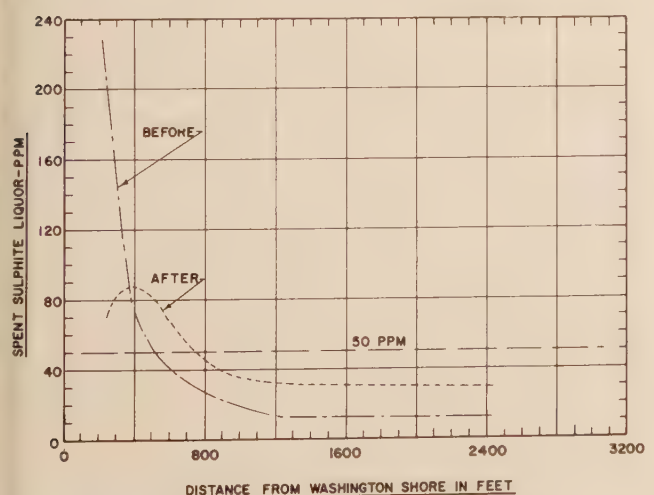

Fig. 7. Absolute maximum spent sulphite liquor concentrations before and after the installation of the underwater diffusion line, 2600 ft. downstream from the outfall

Improvements Observed in the Columbia River After Installation of the Underwater Diffusion Line

Approximately 260 samples were collected at the Seattle, Portland, and Spokane Railroad Bridge (SP & S RR Bridge) after the installation of the underwater diffusion line to ascertain the degree of improvement as effected by the underwater line. This station was 2600 ft. below the outfall of the mill and should be very effective in evaluating the degree of improvement. The mean spent sulphite liquor concentrations at the SP & S RR Bridge before and after operation of the pipe line are shown in Fig. 6. It can be seen that these concentrations were in excess of 50 p.p.m. before the underwater line was put into operation, and as the Washington shore was approached, increased to a value well in excess of 100 p.p.m.

After the installation of the underwater diffusion line the maximum mean value of 51 p.p.m. was recorded 400 ft. from the Washington shore and gradually decreased upon approaching the Washington shoreline. Prior to the installation of the pipe line, maximum spent sulphite liquor concentrations in excess of 200 p.p.m. were not uncommon near the Washington shore, whereas the absolute maximum concentration after installation of the pipe line was approximately 85 p p.m. as shown in Fig. 7. Maximum values in excess of 50 p.p.m. were of short duration once the pipe line was in operation.

There were two contributing factors to maximum concentrations: (1) tidal effects and (2) spent sulphite liquor discharge pattern. Although flood tide was of short duration, usually no longer than 4 hr., for a short period during the flood tide velocity would be reduced to a minimum, thereby increasing the retention of the waste with a consequent increase in waste concentration.

The pulping process, being a batch process, resulted in the discharge of strong liquor for a relatively short period, followed by the diluted wash water. Because of these two factors no attempt was made to evaluate each factor separately. Absolute maximum sulphite liquor concentrations, as well as mean values, are included in Figs. 6 and 7, and the maximum values reflect primarily the influence of tide and waste discharge.

The reduction of spent sulphite liquor pollution as effected by the underwater diffusion line is shown in Fig. 8. In developing this plot, the upstream residual was subtracted from the concentration at the SP & S RR Bridge, 2600 ft. downstream from the underwater outfall. At a distance of 200 ft. from the Washington shore the reduction of pollution was in excess of 90%, and at a distance of 300 ft. from the Washington shore the reduction was approximately 80%. Upon approaching the Washington shore the reduction was found to be in excess of 90%, which clearly demonstrated the effectiveness of the underwater diffusion line in minimizing localized pollution.

The mean spent sulphite liquor distribution pattern after installation of the underwater diffusion line is shown in Fig. 9. From this figure it can be seen that maximum mean waste liquor concentrations of 50 to 55 p.p.m. are recorded at a considerable distance from the Washington shore, and the upper concentration decreases rapidly to a mean of 40 to 50 p.p.m. at a short distance below the SP & S RR Bridge. Although concentrations near the Washington shore are higher than along the Oregon shore, the distribution pattern indicates a more complete utilization of the dilution water than was noted in previous surveys. In general, the critical areas near the shoreline where growth of slime was prolific prior to the installation of the underwater outfall now contain concentrations of spent sulphite liquor below the minimal concentration required for *Sphaerotilus* growth. Although channeling of waste along the Washington shore is still occurring, the concentrations are sufficiently low to prevent excessive slime growths.

DISCUSSION

In most locations the primary problem associated with the discharge of spent sulphite liquor has been oxygen depletion of the receiving water. However, in the Columbia River where flow and velocity are sufficient, oxygen depletion has never been a problem, the dissolved oxygen content always being near the saturation level. However, excessive slime growths in the Columbia River have been attributed to the discharge of spent

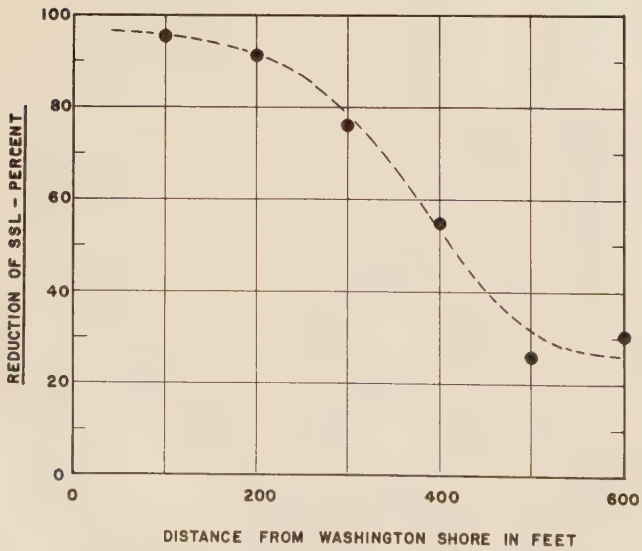

Fig. 8. Reduction of spent sulphite liquor, 2600 ft. below pulp mill outfall, as effected by underwater diffusion line

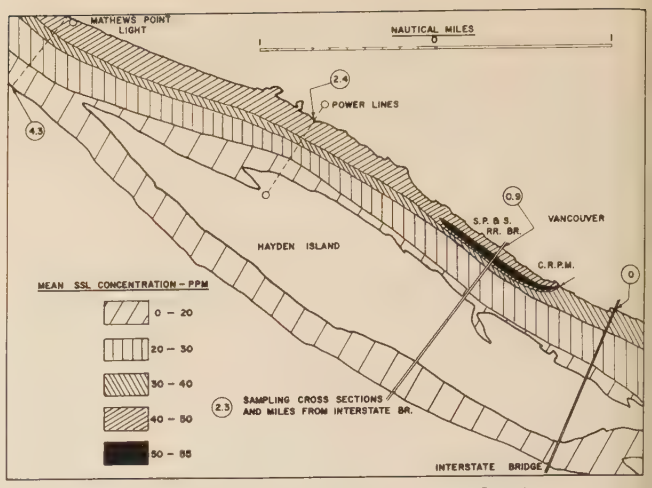

Fig. 9. Mean spent sulphite liquor distribution pattern in the vicinity of the Columbia River Paper Mills after installation of the underwater diffusion line

sulphite liquor. The filamentous bacterial growths, a species of *Sphaerotilus*, during certain periods of the year develop to such quantities that they clog the nets of the commercial fishermen in the area. Studies conducted by Lincoln and Foster (*1*) in 1943 indicated that growth of slime was almost negligible at spent sulphite liquor concentrations below 50 p.p.m., and the organism was dependent upon the sugar fraction in the waste. In other words, the organism is able to develop on an extremely weak substrate of less than 2 p.p.m. of sugar.

There is sufficient water available in the Columbia River for dilution of the waste liquor from present sulphite pulp production provided the waste is brought into intimate contact with the main body of dilution water. Previous surveys have shown that spent liquor discharged close to the shoreline will channel along the shore for more than 10 miles before it is sufficiently diluted below the minimal limit of *Sphaerotilus*.

A number of underwater diffusion lines installed at pulp mill sites along the Columbia have been effective in bringing about rapid mixing and thorough dilution of effluent with dilution water. Based upon the effectiveness of these other installations, it was decided that an underwater disposal line at the Columbia River Paper Mills would be effective in adequately diluting the waste.

Because the channel in front of the Columbia River Paper Mills is dredged at intervals, a line had to be designed that could be removed easily. For this reason the 6-in. rubber reinforced line was chosen. This rubber line has flexibility and can be removed and replaced in one day. In working out the design of the pipe line it was decided that the first 200 ft. of the line would not be used for diffusion because the current studies showed that the velocity of water flow near the shore was very low. The diffusion section, the outer 300 ft. of the 500-ft. line, was chosen as adequate to properly dilute the waste, and a diffusion section in excess of 300-ft. would not offer any material advantage as was shown in Fig. 5.

Stream surveys conducted before and after installation of the underwater line indicated reductions of spent sulphite liquor concentration along the Washington shore in excess of 90%. Maximum concentrations,

lthough low, are found at a considerable distance from he shoreline instead of close to the shore. Prior to the nstallation of the underwater outfall, the spent liquor vould channel close to the shoreline for 7 or 8 miles be- ow the outfall before being diluted below the desired 0 p.p.m. These high concentrations along the shore, vhere means of attachment for the slime organisms vere numerous, resulted in excessive growths. The ilamentous organism would grow to such size along he shore that it could no longer support its weight, at vhich time it would slough off and float downstream. Usually on the ebb tide tremendous quantities of slime ould be seen floating downstream.

The underwater outfall discharging into the main ody of the receiving water has been very effective in educing the substrate concentration below the minimal equirements of *Sphaerotilus*, and although there is till some channelling, the maximum waste concen- ration will be found at a considerable distance from he means of attachment. *Sphaerotilus* will undoubt- dly grow in the flowing stream, but where means of ttachment are not available growth will be limited o small filaments which will cause no serious problem. However, growths afforded attachment near the shore- ne where velocities are relatively low, will accumulate nd "slough" in large slimy masses, causing consider- ble trouble in the sliming of fish nets.

Taking into consideration the upstream residual pent sulphite liquor, it was found that on the aver- ge at a river flow of 100,000 c.f.s. at The Dalles' gage, maximum mean of about 14 p.p.m. of spent sulphite quor was added by the Columbia River Paper Mills t a distance of 2600 ft. downstream from the underwa- r outfall, and the absolute maximum spent sulphite quor concentration was about 30 p.p.m.

It is of interest to note the close agreement between he actual concentration determined by the stream urvey and the theoretical spent sulphite liquor concen- rations calculated from the current studies. For ex- mple, from Fig. 5 it can be seen that with a 300-ft. iffusion section a mean of 20 p.p.m. of spent sulphite quor will be added by the Columbia River Paper Mills n the immediate vicinity of the outfall, assuming per- ct mixing.

SUMMARY AND CONCLUSIONS

A comprehensive survey of the Columbia River in he vicinity of Vancouver, Wash., was started during he Winter of 1953. The purpose of this initial survey as to determine the spent sulphite liquor distribu- on pattern from the Interstate Bridge to a point miles below the outfall of the Columbia River Paper Mills. The data collected during this initial survey ould serve as a base line for comparison with any uture improvements which might be made and would ford information on pollution from upstream sources. urrent studies were also conducted in the vicinity of he proposed pulp mill outfall to determine the quan- ty of dilution water available and to arrive at a ational design for an underwater diffusion line.

After installation of the pipe line a comprehensive mpling program was initiated to ascertain the degree improvement effected by the installation of the nderwater diffusion line. From the extensive stud- ies conducted before and after the installation of the underwater line, the pertinent findings and conclusions are as follows:

1. Based upon a probability study of past records of discharge reflected by the U. S. Geological Survey gaging station at The Dalles, drought severity of 70,- 000 c.f.s. may be expected on the average in the long run during the Fall-Winter season as a minimum daily average once every 3 years, as a minimum weekly av- erage once every 4 years, and as a minimum monthly average once in 8 years. Expressed as a minimum monthly average flow, the most probable drought ex- pected any year is 89,000 c.f.s., and on the average in the long run, 75,000, 68,500, and 62,000 c.f.s. may be expected in 5, 10, and 20 years, respectively.

2. Current studies conducted in front of the Colum- bia River Paper Mills indicated that maximum velo- city was not attained closer than 200 ft. from shore. A 300-ft. diffusion section starting 200 ft. from the pulp mill shore was calculated as necessary to reduce spent sulphite liquor concentrations from the Columbia River Paper Mills to 20 p.p.m. at a river discharge of 135,000 sec.-ft. at The Dalles, assuming perfect mixing. At a discharge of 135,000 c.f.s. at The Dalles, approximately 27,000 c.f.s. of dilution water will flow over the 300-ft. diffusion section.

3. After installation of the underwater diffusion line, 2600 ft. below the pulp mill outfall, the maximum mean spent sulphite liquor concentration of 51 p.p.m. was found 400 ft. from the Washington shore and grad- ually decreased upon approaching the Washington and Oregon shores. The absolute maximum spent sulphite liquor concentration at this location was 85 p.p.m.

4. Taking into consideration the upstream residual a maximum mean spent sulphite liquor concentration of 14 p.p.m. and an absolute maximum of 30 p.p.m. were discharged to the Columbia River by the Colum- bia River Paper Mills at a base flow of 100,000 c.f.s. at The Dalles.

5. Comparison of spent sulphite liquor concentra- tions before and after the installation of the underwater outfall indicated reductions of approximately 90% 0.5 of a mile below the pulp mill outfall. The mean spent sulphite liquor concentration at this location prior to the installation of the pipe line was 100 p.p.m. with maximum concentrations in excess of 200 p.p.m.

6. Mean spent sulphite liquor concentrations along the Washington side of the river from a point 2.7 miles above the pulp mill to approximately 7.5 miles below the pulp mill outfall, were below 55 p.p.m. after the pipe line was placed in operation.

7. The underwater diffusion line has been effective in reducing localized pollution along the Washington shore below the Columbia River Paper Mills' outfall, and concentrations of spent sulphite liquor are con- sidered low enough to prevent excessive slime growths.

LITERATURE CITED

1. Lincoln, J. H., and Foster, R. F., Investigation of Pollution in the Lower Columbia River. Washington State Pollution Control Commission and Oregon Sanitary Authority, 1943.
2. "Big Inches for SWL-Disposal Pipe Line in West," *Pulp Paper* 25, No. 2: 55 (1951).
3. Gumbel, E. J., *Annals of Mathematical Statistics* 12: 163 (1941).

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Performance of Cowan Screens on Kraft Pulp at Crossett Paper Mills

W. S. GARDNER, E. H. SMITH, AND C. L. BROWN

Early experience with Cowan screens on kraft pulp at the Crossett Paper Mills was not satisfactory. Capacity of screens was low and water and power usage was high compared with predicted results and results obtained in other southern mills on kraft pulp. Early experience at this plant was obtained with 0.085-in. perforations on 1/8 or 0.125-in. isometric centers. Later tests with 0.085-in. perforations on 7/32 or 0.219-in. isometric centers indicated a capacity only slightly below that obtained with 0.085-in. perforations on 1/8-in. centers. This change in spacing of perforations gave a tremendous reduction in total number of perforations in a set of plates. A set of Cowan plates with perforations on 1/8-in. isometric centers contains approximately 300,000 perforations while the same plates with perforations on 7/32-in. isometric centers contain approximately 100,000 perforations. Further tests were made with 0.085-in. perforations on 0.1445-in. isometric centers. Immediate results showed greatly improved performance. It was possible to operate the screen at predicted capacity with lower water and power usage than had been necessary for highest tonnage obtained in tests with other plates.

THE design and probably the performance of Cowan screens is familiar to some, but others may not be familiar with design or performance. It has been described earlier as two screens in one, inasmuch as there are two sections; the first acting as a primary screen, and the second as a tailing screen. All incoming pulp enters through an upright ell and hollow shaft section and flows outward through slots placed between the rotor blades. A partial disk baffle in the rotor extending somewhat over halfway from the rotor shaft to the screen plates actually produces the two screening areas. One third of the plate area precedes the baffle and this area, of course, acts as a primary screen. The other two-thirds area following the baffle acts as a tailing screen. The plates are built in conventional design of three 120° sections. Perforations may be one size over the entire width of the plates or may be of two sizes with the dividing line directly over the baffle in the rotor section. All of the plates used at Crossett have been made of 18-gage uncoated stainless steel.

Shower water is admitted at the opposite end of the screen from the pulp inlet and passes through the hollow rotor shaft and outward through 7/8-in. holes placed between the rotor blades in the tailing section only. A narrow baffle is provided between the rotor blades near the periphery of the rotor to give a shallow retention of rejects against plates.

Accepted pulp leaves the screen housing through a tangential outlet at the bottom of the housing. Tailings leave the screen through a rectangular slot in the bottom of the housing.

The first Cowan screen at the Crossett plant, a Mark A or the largest size, was installed and put into operation early in 1950. This screen furnished the extra screening capacity needed in the enlargement of the kraft pulp mill. It was placed to handle pulp from a set of new vacuum brown stock washers and actually received pulp from a high density storage tank followed by a surge tank. A single decker follows this screen. At first rejects from this screen were handled by one old centrifugal screen followed by a two section flat screen. Accepted pulp from the flat screen was returned to the Cowan screen and mixed with incoming pulp.

This screen is operating today in the same manner with the exception of the centrifugal rejects screen. This has been removed and Cowan rejects go directly to the flat screen. It has been found that the situation of this screen makes it well suited for test runs and most of the data presented below were obtained from test runs on this screen.

The engineering for the installation of this screen was predicated upon information furnished by the manufacturer. Upon this basis, water was provided for dilution in the headbox and for the shower in sufficient volume and pressure to handle maximum tonnage to be expected with kraft pulp. Early experience proved very disappointing from a tonnage standpoint, although performance otherwise was satisfactory. Plates with only one size of perforations, 0.085 in., were used as it was found that this perforation gives accepted pulp clean enough for most grades of unbleached kraft pulp.

It was soon learned from test runs that the pulp required a lower consistency than predicted for maximum tonnage, and also, higher shower pressure which, in turn, meant a larger volume of shower water. As might be expected under these conditions, power usage was higher than predicted. For a period of over 2 years this screen was operated at the lower consistency and with the full flow of shower water available. In the meantime three more Mark A Cowan screens were installed in the original screen room as replacements for smaller centrifugal screens. The old water system was able to supply sufficient dilution water but again we were low on shower pressure.

The engineering for all of the Cowan screens was predicated upon a shower pressure of 8 p.s.i.g. maximum and a consistency of 1.25% for incoming pulp. A tonnage of at least 200 air-dry tons per 24 hr. or 8.3 tons per hr. as a sustained rate was expected. Actually the average tonnage was approximately 160 air-dry tons per day or 6.6 tons per hr.

As production gradually increased, sufficient peak capacity, was lacking, and finally last Spring a thorough

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ıvestigation of the screening problems was begun. It 'as known that Cowan screens at other kraft mills in ıe south were operating at predicted capacity of 200 ir-dry tons per day, using plates with 0.085-in. per- ɔrations, and we were advised that the above capacity 'as obtained at approximately 1.2% inlet consistency nd 8 p.s.i.g. shower pressure.

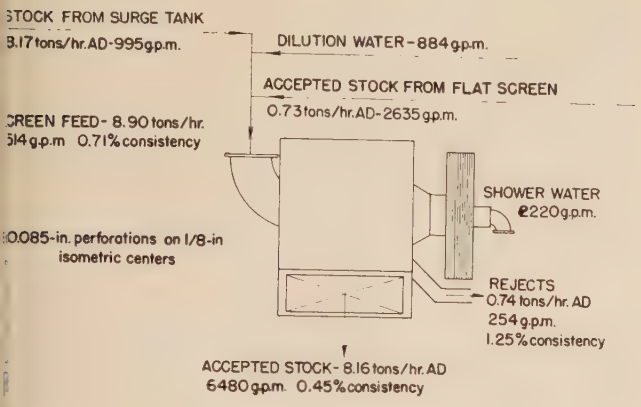

Fig 1

Similar conditions were set up again and again, and lways with the same result. The power requirement 'as too high, the rejects were too rich in pulp, and the ıpacity of the screen exceedingly low. Next the effect f higher shower pressure and lower inlet consistency 'as explored and soon it was determined that optimum ɔnditions for maximum capacity were 0.7 to 0.8% inlet ɔnsistency and 15 p.s.i.g. shower pressure.

As indicated in Fig. 1, with 0.71%* inlet consistency nd 15 p.s.i.g. shower pressure, accepted pulp left the reen at 0.45% consistency, and rejects left the screen t 1.25% consistency and contained 89% pulp. Ac- epted pulp tonnage was 8.16 air-dry tons per hr. and ejected tonnage was 0.74 air-dry ton per hr. or 8.3% f the feed. Total water flow through the plates was 480 g.p.m. and power usage was 0.51 hp.-day per ton. hese conditions were found to exist for maximum ton- age with these plates in many test runs.

It is to be emphasized that the standard screen plate t the Crossett Paper mills for years had been one with t100-in. perforations on $^1/_8$ or 0.125-in. isometric enters. The change to 0.085-in. perforations with the ame spacing for use in the Cowan screen was simply to roduce cleaner accepted pulp. At this point it was ıspected that, due to the close spacing of perfora- ons, capacity was lost through so-called hairpinning of bers in adjacent holes. At about this time, this heory was also suggested from an outside source. The uickest way to prove or disprove this theory was the se of plates with a wider isometric spacing of 0.085- n. perforations. Plates with 0.085-in. perforations on $^7/_{32}$ or 0.219-in. isometric centers were procured. As a uick calculation will show, this was a drastic reduction ı the total number of perforations in a set of plates. ctually, the total number of perforations was reduced rom approximately 300,000 per set to approximately 00,000. Test runs using the plates with $^7/_{32}$-in. spac- ıg indicated that we were on the right track, but ap- arently had made too great a change.

* All consistencies reported in tests are on moisture-free basis.

The optimum conditions for maximum capacity with these plates were 0.81% inlet consistency and 8 p.s.i.g. shower pressure. The accepted pulp left the screen at 0.53% consistency and the rejects left the screen at 0.66% consistency, containing 75% pulp. Accepted pulp tonnage was 6.87 air-dry tons per hr. and rejected tonnage was 0.51 air-dry tons per hr. or 6.9% of the feed. Total water flow through the plates was 4670 g.p.m. and power usage was 0.61 hp.-day per ton. These conditions and results were found to exist for maximum tonnage through these plates in many test runs.

The next step was the testing of plates with 0.085-in. perforations on 0.1445-in. isometric centers. This spacing may be expressed also as $^1/_8$ in. between adjacent rows of perforations. These plates contained approximately 230,000 perforations per set of plates. Operation with these plates proved immediately that their performance was far superior to that of the other plates.

The optimum conditions by which it was possible to obtain predicted capacity at approximately recommended conditions were determined. The inlet consistency was 1.2% and shower pressure was 9. p.s.i.g. The accepted pulp left the screen at 0.80% consistency and the rejects left the screen at 1.71% consistency, containing 82% of pulp. Accepted pulp tonnage was 9.97 air-dry tons per hr. and rejected tonnage was 0.99 air-dry ton per hr. or 9.0% of the feed. Total water flow through the plates was 4480 g.p.m. The rejects were still too rich in pulp but this has not presented too much difficulty.

The horsepower attached to the Cowan screens has

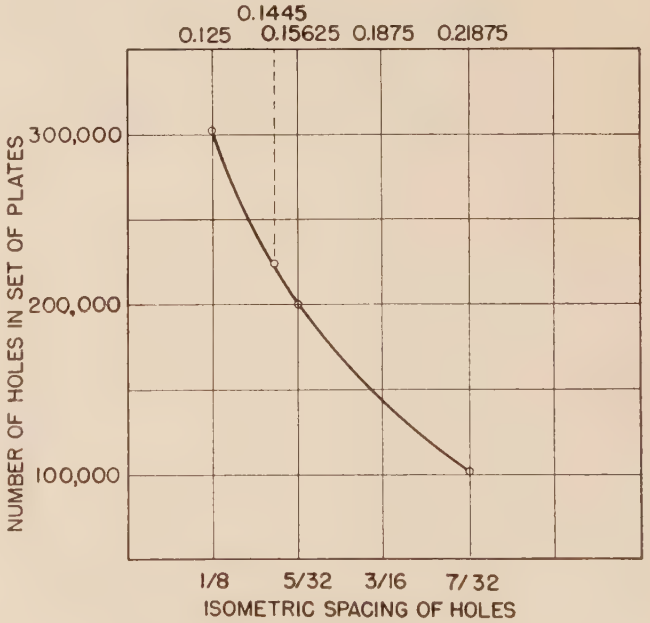

Fig 2

not been mentioned, but all of the screens are and have been equipped with 100-hp. motors. When operating with plates with $^1/_8$ and $^7/_{32}$-in. spacing of perforations, full horsepower could not be utilized due to insufficient decker capacity or rejects handling equipment. Operation with plates with 0.1445-in. spacing of perforations has shown that 90 hp. is consumed at a screening rate of 240 air-dry tons of accepted pulp per day. This

gives a power consumption of 0.38 hp.-day per ton. It is realized that this power usage is rather high compared with reported usage of 0.33 hp.-day per ton, but it is slightly below manufacturer's predicted figure of 0.40-hp.-day per ton.

The total rejects in pulp entering screens averaged about 1.2% as separated by a 10-cut flat screen.

The average permanganate number of our pulp ranges from 26 to 28 TAPPI Standard. When testing plates with $^1/_8$-in. spacing of perforations, a series of cooks were made which gave a pulp with 21 to 22 permanganate number in order to determine the influence of this factor on Cowan screen performance. Tests with this pulp showed little if any increase in screen capacity contrary to expectations. The plates with 0.1445-in. spacing of perforations on the lower permanganate number pulp have not been tested yet.

Figure 2 shows the relationship between the total number of isometric perforations in a set of Cowan Mark A screen plates and their spacing for the range explored. A glance at the chart shows that as the width of the flat metal between perforations approaches the diameter of the perforations, a slight change in the spacing produces a very large change in the total number of perforations. Recent tests have shown that for our pulp there is definitely an optimum spacing of perforations. It is not known what inherent quality of the pulp is responsible for its peculiar screening characteristic.

Since the first tests with the plates with 0.1445-in. spacing of perforations, like plates have been installed in all of the Cowan screens, and the test results have been confirmed with sustained mill scale operation.

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Rosin from Jeffrey Pine Stump Wood

ARTHUR B. ANDERSON

The forest products industries are attempting to find uses for the logging residues left in the forest. This preliminary investigation was undertaken to evaluate the extractives present in Jeffrey pine stumps as a possible source of chemical products. The heartwood of well-seasoned Jeffrey pine stumps was found to contain about 26% benzene-soluble extractive material. Over one half of the extract consists of resin acids and upon refining the crude extract by commercially used processes, good recoveries of refined wood rosin were obtained. The properties and characteristics of the rosin, so prepared, are comparable to those of commercially produced refined wood rosins. The rosin contains about 80% resin acids, and they are of the diterpenic type. Of the total resin acids present, approximately 58% appears to be of the two double bond abietic acid type.

Chemical characterization of the extractive components present in wood residues from lumbering and logging operations is one of several methods available to ascertain whether such material has use as a potential source of chemical products. And it is generally known that in any one species, in particular the pines, the richest quantity of wood extract is usually found in the butt heartwood. Thus, it becomes apparent that in logging old growth stands of pine timber, the greater yields of potentially valuable products are to be found in neglected stumps. The present exploratory investigation was undertaken to determine whether Jeffrey pine stumps (*Pinus jeffreyi* Grev. and Balf.) might serve as a useful raw material in the diversified field of forest products chemical industries.

Certain species of stump wood are being harvested and processed for their extractive components. Old growth southern pine stumps (*Pinus palustris* Miller and *Pinus caribaea* Morelet) have been used for over 40 years for the recovery of wood rosin, turpentine, and pine oil, which augments the naval stores supplied by the living tree (*20*). The supply of old growth southern pine stump wood suitable for wood naval stores, however, is gradually being depleted. A recent forest survey in Mississippi, which supplies about 17 and 10%, respectively, of the total United States supply of wood rosin and turpentine, revealed that the total remaining supply of suitable stumps is about $6^1/_2$ million tons, roughly enough for 10 to 15 more years of production under present production rates (*25*). Recently, ponderosa pine (*Pinus ponderosa* Laws) stump wood has been found to be a good source of rosin and volatile terpenes (*2*) and a commercial extraction plant is processing this material (*26*). Still more recently, sugar pine (*Pinus lambertiana* Dougl.) stumps were found to be a rich source of the water-soluble cyclitol, pinitol (*3*).

Jeffrey pine is found largely in California and extends into southern Oregon. This commercial timber species which generally grows in mixed stands of ponderosa pine is morphologically closely related to the latter. No attempt is made to segregate the lumber produced from these two species. However, the chemistry of the volatile oils obtained from each readily distinguishes these pines. The volatile oil fraction from Jeffrey pine oleoresin contains about 95% *n*-heptane and 5% aliphatic aldehydes, while the volatile portion from ponderosa pine oleoresin is terpenic in nature (*7, 19, 22, 23*). Leuchtenberger appears to be the first to have investigated the resin acids present in Jeffrey pine oleoresin, and he reported the presence of C_{10} and several C_{18} acids (*15*). Later examination by Schorger, however, indicated that these resin acids are largely diterpenic, $C_{20}H_{30}O_2$ (*22*). Adams investigated the volatile oil obtained by direct distillation of Jeffrey pinewood and found that the composition was comparable to the volatiles from the oleoresin (*1*). More recently, Lindstedt determined the nature of the phenolic constituents present in Jeffrey pine heartwood and was able to isolate and identify two products, namely pinocembrin and pinosylvin monomethyl ether (*16*). Later, Lindstedt and Misiorny, using chromatographic technique, indi-

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ated that, in addition to the previously mentioned henols, pinosylvin and tectochrysin were also present 17). This appears to be the first investigation rela- ive to the nature of the extractive components present n Jeffrey pine stump heartwood.

METHOD OF SAMPLING

The practice of the stump wood processing industries s to allow the stump to remain in the ground for about 0 years or so before processing. This time interval ermits the bark and decay-susceptible sapwood to eparate, leaving the sound heartwood intact, which is ich in resinous components. The harvested stumps re shipped to the plant, chipped, and extracted with a uitable solvent, such as a petroleum hydrocarbon or enzene, to recover the extractives. The stumps used n this investigation had seasoned a minimum of 7 ears.

Five or six Jeffrey pine stumps, chosen at random, ere sampled from three widely separated sites in Cali- ornia, namely Black's Mountain, Westwood, and the ake Tahoe region. Trained and experienced foresters ollected the samples. In the few instances where the apwood was still intact, it was removed prior to taking he sample. A composite sample of each stump was btained by making a vertical cut through the diameter f the stump with a power saw to approximate round level. The cuttings were collected on a tar- aulin. Then a similar cut was made perpendicular o the first cut. The cuttings from each stump were ombined and transferred to glass containers and sealed.

AMOUNT OF EXTRACT

Twenty to twenty-five grams of power-saw cuttings ere weighed, in duplicate, in extraction thimbles and

able I. Benzene-Soluble Extract in Jeffrey Pine Stumps

Site	Years stump seasoned	Stump no.	Diam. of sound core, in.	Extractive, %: Dry basis	Extractive, %: Air-dry basis
lack's	11	1	22	21.7	17.2
Mountain		2	20	31.3	25.6
		3	24	33.2	28.4
		4	18	36.2	31.3
		5	20	20.2	16.5
		6	20	36.2	29.5
			Av.	29.8	24.7
Vestwood	34	1	28	42.2	41.7
		2	16	31.4	28.9
		3	7	26.5	24.3
		4	10	23.7	21.8
		5	14	27.6	25.3
			Av.	30.3	28.4
ake Tahoe	7	1	19	25.9	24.1
		2	16	37.5	34.9
		3	22	33.2	30.8
		4	10	24.4	22.1
		5	17	30.7	28.0
			Av.	30.5	27.9
			General av.	30.2	26.9

xtracted with benzene for 8 hr. in Soxhlet extractors. he solution in the flask containing the extract was ransferred to a 100-ml. volumetric flask and diluted to olume with benzene. Two 10-ml. aliquots were with- rawn and transferred to tared flasks, the benzene dis- lled from a water bath, and the flask containing the esidue dried in a vacuum oven at 80°C. to constant eight. The amount of benzene-soluble extract ob- tained from the various stump samples is reported in Table I.

The yields of extract ranged from 20.2 to 42.2% or an average of 30.2% (moisture-free basis). This corresponds to about 26 to 27% yield of extract based on the air-dry weight of the samples or approximately 530 lb. of extract per ton of stump wood. This yield compares favorably with the amount of crude resinous extract (excluding volatiles) obtained from ponderosa pine (23%) (*2*) and southern pine stumps (26%) (*13*).

NATURE OF BENZENE EXTRACT

A composite sample of extract from each of the three sites was prepared by combining the benzene extracts remaining after the previously described determinations. The benzene was distilled from a water bath and 5 to 8 grams of the extract was taken up in ethyl ether and separated into the various components in accordance with the method outlined in Fig. 1 and as described for the analysis of ponderosa pine stump wood extract (*2*). The percentage composition of the extracts from each of the three sites is summarized in Table II.

Table II. Composition of Stump Extractives in Per Cent

Site	Resin acids	Fatty acids	Other acids	Phenolics	Combined acids	Unsaponifiable
Black's Mountain	58.4	4.7	16.9	6.2	6.4	7.4
Westwood	57.3	2.6	17.8	8.6	5.3	8.4
Lake Tahoe	59.8	6.6	11.4	8.1	5.4	8.7
Av.	58.5	4.6	15.4	7.6	5.7	8.2

While the heartwood from freshly cut Jeffrey pine is known to contain steam volatile components, of which 95% is *n*-heptane (*1*), the well-seasoned stump heartwood examined contained but traces of volatile product. Direct steam distillation of 100 grams of stump wood samples produced only from traces to 0.3 ml. of a volatile oil. This small amount of product was not included in the present analysis. Well-seasoned ponderosa pine stump wood, on the other hand, yields an extract which contains about 10% volatile terpenes (*2*).

The predominating component in Jeffrey pine extract is resin acids, which accounts for about 58% of the components present in the benzene-soluble material. As will be shown later, these resin acids are of the diterpenic type, $C_{20}H_{30}O_2$, having a neutral equivalent of 302, theory for abietic acid 302. The acid fraction, which was soluble in Na_2CO_3 solution, amounting to 15.4% of the total extract, had neutral equivalents varying from 333 to 361. These may possibly include oxidized resin acids since 81% were found to be insoluble in petroleum ether. On the other hand, the resin acids recovered from cyclohexylamine salts, contained but a trace of petroleum ether-insoluble material.

The phenolic fraction (sodium hydroxide soluble) gave an intense brick-red color when treated with a solution of bis-diazotized benzidene (*14*). Upon submitting this fraction to the chromatographic method developed by Lindstedt (*16, 17*), spots were found at Rf values 0.05, 0.13, 0.43, and 0.73, which indicate the presence of the phenolic constituents pinosylvin, pinobanksin, pinocembrin, and pinosylvin monomethyl ether, respectively.

Crude southern pinewood rosin is composed of approximately 85% acids (largely resin acids), 5% esters, and 10% resenes (*8*). Thus the over-all composition of the benzene-soluble extract from Jeffrey pine suggests that it would be amenable to refining methods for the production of a refined wood rosin.

REFINING OF CRUDE JEFFREY PINE ROSIN

The two commercially successful processes developed for refining crude wood rosin depend upon the removal of color bodies or oxidized constituents either by an adsorbent such as fuller's earth (*20*) or by the selective solvent action of furfural (*13*). Each of these methods was used in the present investigation in refining the crude benzene-soluble extract obtained from Jeffrey pine stump wood.

A composite of all the stump wood samples collected from each of the three sites was prepared. Four 500-gram batches of the composite sample were placed in cloth bags and extracted in Soxhlet extractors with benzene for 16 hr. Most of the benzene was removed from the combined extracts by distillation from a water bath. The concentrated benzene extract was transferred to a 1-liter three-neck round bottom flask fitted with thermometer and steam inlet tube. The flask was heated by a Glas-Col mantle heater and when the temperature of the residue in the flask reached 150°C., steam was passed through the extract until all volatiles were removed. Upon completing the distillation, the hot, dark amber residue was poured into paper boats and allowed to cool. The crude rosin weighed 530 grams or 26.5% yield (air-dry weight of stump wood).

Several volumes of petroleum naphtha (b.p. 175–215°F.) were added to 400 grams of crushed crude rosin and refluxed on a water bath to dissolve the extract. This was cooled to room temperature and additional petroleum naphtha added to make approximately a 15% solution of rosin. After the insoluble material had settled, the clear amber solution was decanted and used for subsequent refining. The petroleum naphtha-insoluble material amounted to 11% of the total crude benzene-soluble extract.

REFINING WITH FILTEROL

A slurry of 100 grams of Super-Filterol F.O. (Filtrol Corp.) in petroleum naphtha was carefully poured into a chromatographic column (44 by 270 mm.). After the adsorbent had settled, 1000 ml. of the 15% rosin petroleum naphtha solution was passed through the column and collected in a filter flask using slight vacuum. As the rosin solution moved through the column, the upper portion of the adsorbent became blue-gray. The blue-gray band became wider as the rosin solution continued to pass through the adsorbent. This adsorbed color later proved to be due to oxidized colored material present in the crude rosin extract. After most of the 1000 ml. of rosin solution had passed through the column, the filterol was washed with 500 ml. of petroleum naphtha. The naphtha solutions were combined and the solvent removed by distillation, followed by steam distillation of the product at 150°C. The hot residue was poured into paper boats and allowed to cool.

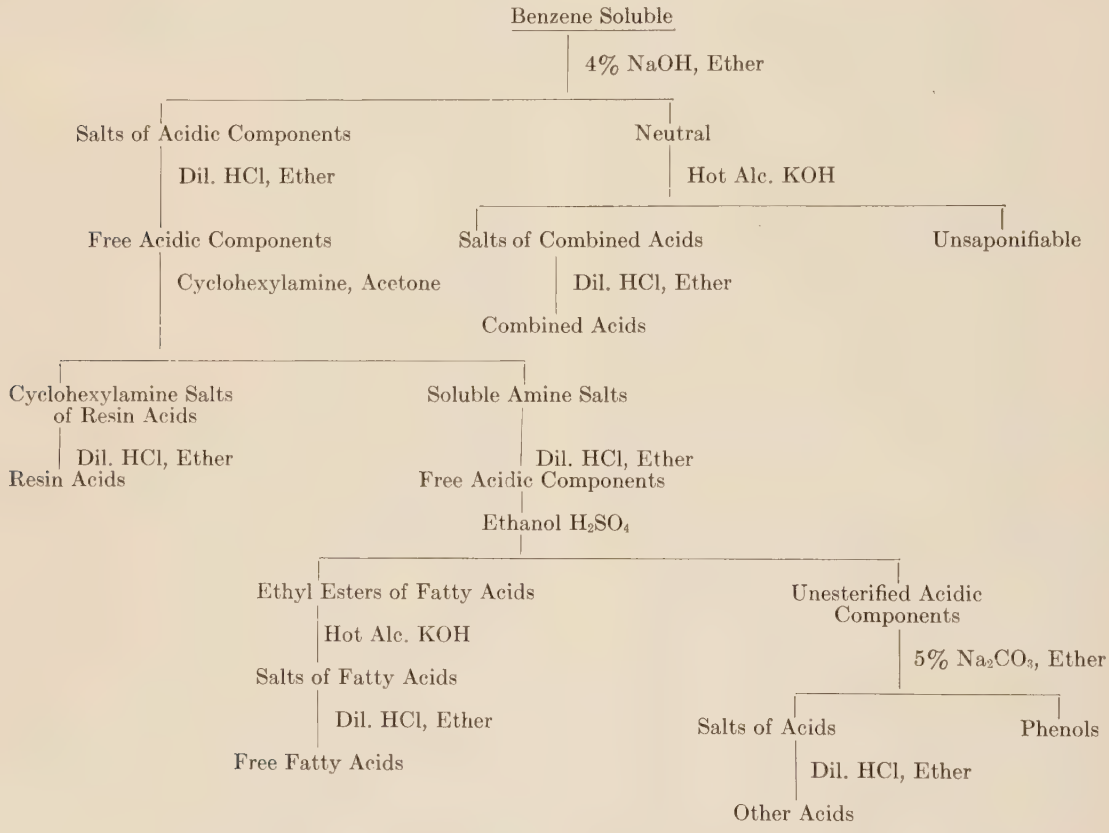

Fig. 1. Separation of benzene-soluble components

Table III. Properties of Jeffrey Pinewood Rosins

Rosin	Colorgrade	Acid no.	Sapon. no.	Unsapon., %	Pet. ether insol., %	Softening pt., °C.	$[\alpha]^{22}_{D}$ [a]	Resin acid, %[b]
Jeffrey pine filterol	N	165	167	6.0	0.41	72.0	−10	82.7
Jeffrey pine furfural	N	160	170	6.3	Trace	71.0	−7	80.8
Hercules	N	166	172	5.8	0.70	74.0	−5	86.7
			Colored Extracted Resins					
Jeffrey pine filterol	Too dark	131	..	7.3	61.4	89–96	..	24.2
Jeffrey pine furfural	Too dark	140	..	8.3	75.3	78–83	..	31.7

[a] One per cent solution in absolute ethyl alcohol.
[b] Cyclohexylamine salt, Harris method (*10*).

The recovery of filterol refined rosin amounted to 80% of the total naphtha-soluble material, with color corresponding to N grade wood rosin (compared with rosin standards). The adsorbed resin, containing the highly nctorial oxidized material, was eluted from the column y washing the adsorbent with 500 ml. of 35% absolute lcohol in petroleum naphtha (*20*). The dark colored sin was recovered by distilling the solvent and then eam distilling the residue at 150°C. The hot material as poured into paper boats and cooled.

REFINING WITH FURFURAL

One liter of 15% solution of rosin in petroleum aphtha and 100 ml. furfural (The Quaker Oats Co.) ere put in a 2-liter Erlenmeyer flask and the contents eated to a point of miscibility, i.e., 65 to 70°C., for veral minutes with stirring. The homogeneous solution was cooled to 20°C., under tap water, transferred a separatory funnel, and the lower dark-colored furfural layer drawn off. The furfural treatment was peated a total of three times. The furfural solutions ere combined and extracted three times with 100-ml. ortions of petroleum naphtha and the latter washings mbined with the furfural-extracted naphtha solution. he petroleum naphtha was removed by distillation nd the residual solvent and small amount of dissolved rfural removed by steam distillation. Steam distillation was continued at 150°C. until the distillate no nger gave a test for furfural with aniline-acetate paper. pon completing the distillation, the dry hot residue as poured into paper boats and allowed to cool. he color of the refined rosin, so obtained, was equivant to N grade rosin and the recovery amounted to out 75% of the total naphtha-soluble resin. The rfural containing the dissolved color bodies was reoved by steam distillation at 150°C., and the residue oured into paper boats as before.

PROPERTIES OF ROSINS

The characteristics of the refined Jeffrey pine wood sins and extracted highly colored resins were compared with the corresponding properties of N wood sin (Hercules Powder Co.) obtained from southern ne stump wood. Grade, acid number, saponification umber, unsaponifiable, and softening point (ring and all) were determined by ASTM methods. Optical tations were determined on 1% solution of the rosins absolute ethanol. The percentage of resin acids was stimated by the cyclohexylamine salt method of Harris (*10*). The results are given in Table III.

As indicated in Table III, the properties of the refined Jeffrey pine wood rosins compare favorably with those of N southern pine wood rosin. While there may be slight variations in characteristics of the rosins, these properties can largely be governed, such as color, acid number, and softening point, by the degree of refining and methods of treatment to which the material is subjected (*13, 20, 24*). Thus, these preliminary results would suggest that the presently neglected Jeffrey pine stump wood can join the present sources of raw material, i.e., old growth southern pine stump wood in the southeast and ponderosa pine stump in the western states, as a commercial source of wood rosin.

NATURE OF RESIN ACIDS IN REFINED ROSIN

Harris has shown that southern pine wood resin acids consist of eight diterpenic acids (*11*). Three of these are of the two double bond abietic type acids, namely 1-abietic (30 to 40%), neoabietic (10 to 20%), and levopimaric (less than 0.1%). These abietic type acids may be classified as maleic anhydride reactive since an acid-isomerized mixture of the three acids will react with maleic anhydride to form the same philodiene adduct as levopimaric acid (*12*). This resin acid adduct can be readily separated from the unreacted acids by virtue of the difference in solubility in certain solvents. Thus, Fleck and Palkin determined the amount of levopimaric present in pine oleoresin by quantitatively precipitating maleo-levopimaric acid at room temperature from *n*-pentane solutions containing the reaction mixture (*5*). Other solvents are equally effective, namely petroleum ether, *n*-heptane, and *n*-hexane (*6*). The insolubility of the maleic anhydride adduct in *n*-hexane was employed in the present investigation to estimate the amount of two double bond abietic type acids present in Jeffrey pine wood resin acids.

Isolation of Resin Acids

Two hundred grams of Jeffrey pine wood rosin, acid number 162, was dissolved in 600 grams of acetone by warming on a water bath. A solution of 45 grams of cyclohexylamine (Monsanto Chemical Co.) in 45 grams of acetone was added to the warm solution with stirring (*10*). The solution containing the crystalline mass was cooled to room temperature, filtered, and the salt washed with 200 ml. acetone. The salt was air dried and then suspended in 1 liter of ethyl ether in a separatory funnel and shaken vigorously with a 10% solution of hydrochloric acid until the amine salts had disappeared. The aqueous acid solution was withdrawn and the ether solution was washed twice with dilute hydrochloric acid, followed by water until the washings were neutral to Congo Red. The ether solution of resin acids was transferred to a flask and the ether distilled from a water bath. The resin acid resi-

due was again dissolved in 600 grams of acetone and the acids reprecipitated with cyclohexylamine. The salts were decomposed in ethyl ether as before and the ether solution dried over anhydrous sodium sulphate. The ether was removed by distillation in the presence of carbon dioxide and the last trace of solvent removed by heating under aspirator pump vacuum at 150°C. The hot viscous resin acid liquid was poured into paper boats and blanketed with carbon dioxide until cool. Obtained, 156 grams of pale amber resin acids (78% of total refined rosin), with acid number 185 and neutral equivalent 302, $[\alpha]_D^{22}$ −20 (1% in absolute alcohol).

ISOLATION OF MALEIC ANHYDRIDE RESIN ACID ADDUCT

Ten grams of Jeffrey pine resin acids, acid number 185, and 10.0 grams of maleic anhydride in 50 ml. of benzene saturated with dry hydrogen chloride were refluxed for 50 hr. (*12*). The acid number of the reaction mixture, free of maleic anhydride at this point, was 311, as determined in a duplicate reaction run. Further refluxing for an additional 50 hr. did not increase the acid number, indicating that the reaction had been completed at the end of 50 hr. This increase in acid number from 185 to 311, according to the method employed by Sandermann, would indicate that 58% of the original resin acids present had reacted with maleic anhydride to form the adduct (*21*).

After the completion of the reaction (i.e., 50 hr.) one half or 25 ml. of benzene was removed by distillation, and the concentrated reaction mixture poured, with stirring, into 350 ml. of *n*-hexane to precipitate the adduct. The entire mixture was permitted to set in an ice box overnight and then the clear solution decanted into a separatory funnel. The insoluble residue was washed with several small portions of *n*-hexane and the washings added to the decanted solution. The combined *n*-hexane solution was extracted several times with water until neutral to Congo Red, then transferred to a tared flask and the solvent removed by distillation from a water bath. The flask containing the residue was dried in a 105°C. oven for 4 hr., cooled and weighed. The unreacted resin acids weighed 4.20 grams, which represents 42% of the total resin acids present, which had not undergone the Diels-Alder reaction. This agrees favorably with the acid number found (i.e., 311) at the close of the reaction (i.e., 58% as adduct).

The *n*-hexane-insoluble residue remaining in the flask was taken up in ethyl ether, transferred to a separatory funnel, and washed with water until neutral to Congo Red. The ether solution was dried over anhydrous Na_2SO_4, filtered, and ether distilled from a tared flask on a water bath, then dried in an 105°C. oven for 4 hr., cooled and weighed. The crude adduct weighed 7.45 grams, which is equivalent to 5.62 grams as abietic type acids or 97% of calculated.

*Isolation of Maleo-levopimaric Acid**

Fifteen milliliters of glacial acetic acid was added to the crude adduct and dissolved by warming on a steam bath. This was allowed to cool to room temperature, where on scratching produced a heavy white crystalline precipitate. This was allowed to stand several hours, then filtered and washed with 15 ml. of 95% glacial acetic acid, followed by *n*-hexane. The crystalline product was dried in an 120°C. oven. Weight was 4.61 grams or 62% recovery with m.p. 220–222°C. The product was again recrystallized from glacial acetic acid, followed by absolute ethyl ether-*n*-hexane, giving a product of constant m.p. 226–227°C., $[\alpha]_D^{22}$ −28 (10% in chloroform) (*4*).

Anal. Calcd. for $C_{24}H_{32}O_5$(400): C, 71.96; H, 8.06. Found: C, 72.13; H, 7.98; mol. wt. 414 (from neut. equiv.) (titrated in 70% acetone) (calc. mol. wt. for corresponding tribasic acid $C_{24}H_{34}O_6$ = 418).

Mixed melting point unchanged with authentic maleo-levopimaric acid.

The purified adduct was further identified as maleo-levo-pimaric acid by converting it to its methyl ester by reaction of the adduct with phosphorus trichloride followed by refluxing with methyl alcohol (*9*). Mixed melting point, 216–217°C., with authentic sample of the methyl ester of maleo-levo-pimaric acid remained unchanged.

This preliminary investigation as to the nature of the resin acids present in refined Jeffrey pinewood rosin indicates that about 58% are of the two double bond abietic acid type. Southern pine wood rosin resin acids, on the other hand, consist of approximately 50% of this type of resin acid, namely l-abietic and neoabietic acids (*11*). Further characterization of the resin acids in Jeffrey pine rosin and extract is presently under investigation.

LITERATURE CITED

1. Adams, M. J., *Ind. Eng. Chem.* 7: 957 (1915).
2. Anderson, A. B., *Ind. Eng. Chem.* 39: 1664 (1947); *Paper Trade J.* 129, No. 2: 35 (1949).
3. Anderson, A. B., *Ind. Eng. Chem.* 45: 593 (1953).
4. Bacon, R., and Ruzicka, L., *Chem. Ind.* 1936: 546.
5. Fleck, E. F., and Palkin, S., *Ind. Eng. Chem., Anal. Ed.* 14: 146 (1942).
6. Fleck, E. F., U. S. pat. 2,359,980 (Oct. 10, 1944).
7. Foote, P. A., *J. Am. Pharm. Assoc.* 18: 350–353 (1929).
8. Georgi, E. A., *Paper Trade J.* 100, No. 12: TAPPI Sec. 156–158 (1935).
9. Griff, M. M., *J.A.C.S.* 68: 1937 (1946).
10. Harris, G. C., U. S. pat. 2,419,211 (April 22, 1947). Harris, G. C., and Sanderson, T. F., *J.A.C.S.* 70: 334–339 (1948).
11. Harris, G. C., Chapter VIII, Wood Resins, pp. 167–177, "Nature of the Chemical Components of Wood," TAPPI Monograph Series No. 6, 1948, New York, N. Y.
12. Harris, G. C., and Sanderson, T. F., *J.A.C.S.* 70: 2079–2081 (1948).
13. Humphrey, I. W., *Ind. Eng. Chem.* 35: 1063 (1943).
14. Koch, J. E., and Kreig, W., *Chem. Ztg.* 62: 140 (1938).
15. Leuchtenberger, C., *Arch. Pharm.* 245: 701 (1907).
16. Lindstedt, G., *Acta Chem. Scand.* 3: 770–772 (1949).
17. Lindstedt, G., and Misiorny, A., *Acta Chem. Scand.* 5: 123 (1951).
18. Lindstedt, G., *Acta Chem. Scand.* 4: 448–455 (1950).
19. Mirov, N. T., *J. Forestry* 27: 176–187 (1929); *ibid.* 40: 953–954 (1942).
20. Palmer, R. C., *Ind. Eng. Chem.* 26: 703 (1934).
21. Sandermann, W., *Ber.* 71: 2005 (1938); *Bull. Inst. Pin.* 3, No. 31: 137 (1937).
22. Schorger, A. W., *Ind. Eng. Chem.* 5: 971 (1913).
23. Schorger, A. W., *Proc. Soc. Am. Foresters* 11: 33–39 (1916).
24. Stinson, J. S., and Laurence, R. V., *Ind. Eng. Chem.* 46: 784–787 (1954).
25. Stover, W. S., *Naval Stores Rev.* 59: 48 (1950) (14–15; 24–25).
26. *Timberman* 50: 105 (Oct., 1950).
27. Weinhaus, H., and Sandermann, W., *Ber.* 69: 2202 (1936).

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* All melting points taken on Fisher-Johns melting point block; microanalysis by Microchemical Laboratory, University of California.

ASSOCIATION NEWS AND EVENTS

Local Section Meetings

Maine-New Hampshire: Sept. 10–11, 1954, Madawaska Inn, Edmundston, N. B.

Southeastern: Sept. 17–18, 1954, Valdosta, Ga.

Fundamental Research Conference

The Fundamental Research Committee of the Technical Association of the Pulp and Paper Industry and the Technical Section of the Canadian Pulp and Paper Association will sponsor a conference on the Fundamentals of the Paper Machine at The Institute of Paper Chemistry, Appleton, Wis., on Sept. 20–24, 1954.

September 20 will be devoted to registration and inspection tours of The Institute of Paper Chemistry.

Sept. 21, 1954

9:00 a.m. Welcome Addresses by the Committee Chairman: K. C. Logan, Northeastern Paper Products Ltd., Quebec, P. Q., and H. F. Lewis, Institute of Paper Chemistry, Appleton, Wis.

9:15 a.m. "Flow in Fiber Suspensions and the Effect of Turbulence," by J. A. Van den Akker, Institute of Paper Chemistry, Appleton, Wis.

10:15 a.m. "Model Particle Behavior and Flocculation," by S. G. Mason, Pulp and Paper Research Institute of Canada, Montreal, P. Q.

11:15 a.m. "The Hydrodynamics of the Headbox and the Slice," by W. van der Meer, Van Gelder Zonen, N. V., Velsen, Holland.

1:30 p.m. "Model Experiments of Sheet Formation on the Cylinder Wire," by Böorje Steenberg, Jan Bergström, and R. I. Kjensjord, Swedish Forest Products Laboratory, Stockholm, Sweden.

2:15 p.m. "The Evaluation of Paper Machine Stock Systems by Basis Weight Analysis," by George Burkhard and Peter Wrist, Quebec North Shore Paper Co., Baie Comeau, P. Q.

3:00 p.m. Panel Discussion on the above papers.

Sept. 22, 1954

9:00 a.m. "Theory and Application of the Concept of Filtration," by Roy P. Whitney and William L. Ingmanson, Institute of Paper Chemistry, Appleton, Wis.

9:45 a.m. "Water Removal by Table Rolls," by W. E. Bennett, British Paper & Board Industry Research Association, Kenley, Surrey, England.

11:00 a.m. "Influence of Differential Speeds Between Stock and Wire on Sheet Properties," by O. Andersson, Swedish Forest Products Laboratory, Stockholm, Sweden.

1:30 p.m. "Stroboscopic Observations of the Wet End," by C. C. Porter, Southland Paper Mills, Lufkin, Tex.

2:00 p.m. "Water Removal and Two-Sidedness," by George F. Underhay, Bowaters Development and Research Ltd., London, England.

3:00 p.m. Panel Discussion on the above papers.

Sept. 23, 1954

9:00 a.m. "Fiber Properties Involved in Adhesion and Cohesion with Reference to Wet Web Strength," by Wilfred Gallay, The E. B. Eddy Co., Hull, P. Q.

9:45 a.m. "The Function of the Felt in Water Removal on the Papermaking Machine," by Alfred H. Nissan, Department of Textile Industries, The University, Leeds, England.

11:00 a.m. "Laboratory Investigation of Water Removal by a Dynamic Suction Box," by Lars Nordman, Central Laboratory of Finland, Helsingfors, Finland.

1:30 p.m. "Effect of Water Removal on Sheet Properties," by H. F. Rance, Wiggins Teape Group Research Organization, High Wycombe, Bucks, England.

3:00 p.m. Discussion on the above papers.

Sept. 24, 1954

9:00 a.m. "The Effect of Wet Pressing on Sheet Properties," by D. J. MacLaurin, Institute of Paper Chemistry, Appleton, Wis.

9:45 a.m. "Introduction of Strains into the Sheet on Drying," by Bertill Ivarsson, Swedish Forest Products Laboratory, Stockholm, Sweden.

11:00 a.m. "Measurement of Draws and Machine Speed Variations," by Dalton L. Shinn, Crown Zellerbach Corp., Camas, Wash.

1:30 p.m. "Elastic Theory of Nips with Practical Applications," by Homer E. Malmstrom, Kimberly-Clark Corp., Neenah, Wis., and John P. Nash, University of Illinois, Urbana, Ill.

3:00 p.m. Panel Discussion on the above papers.

Note: Attendance at these open meetings of the two committees will be limited to 200 individuals. Further information in regard to this symposium may be obtained from Harry F. Lewis, The Institute of Paper Chemistry, Appleton, Wis., or from K. C. Logan, P. O. Box 1456, Quebec, P. Q., Canada, the chairmen of the respective committees.

This conference is the second in a series. The first conference was held in Quebec, P. Q., in May, 1950, on the theme: "Effect of Fiber Characteristics on Paper and Papermaking Properties" (see *Tappi*, August and September, 1950).

Testing Conference

The Testing Division with assistance by the TAPPI Ohio Section is preparing a conference to be held at the Dayton-Biltmore Hotel, Dayton, Ohio, on Oct. 6–8, 1954.

The program for October 6 consists of meetings by the Paper Testing, Nonfibrous Materials Testing, Pulp Testing, Optical Properties, Microscopy, Packaging Materials Testing, Chemical Methods, and TAPPI-ASTM Joint Technical Committee on Petroleum Wax.

The meeting on October 7 will be featured by a series of talks on new testing tools. It is expected that these talks will cover such subjects as spectroscopy, absorption spectrometry, electron microscopy, chemical microscopy, potentiometric titration, chromatography, ion exchange, microchemistry, polarography, etc.

These are subjects with which papermill chemists are unfamiliar. It is hoped that speakers can be obtained who will present these subjects briefly, describing how the tests are made, the theory behind them, and the meaning of the results.

The October 8 program will be devoted to committee meetings. It is possible that plant visits will be arranged to inspect the plants of McCall Publishing Co. and the National Cash Register Co.

Chesapeake and Allegheny

On May 21-22, 1954, a steering committee consisting of:

Roy Traver, Camp Manufacturing Co., Franklin, Va.
Julian Weaver, Froehling & Robertson, Richmond, Va.
John Priest, Halifax Paper Co., Roanoke Rapids, N. C.
William Jones, National Bureau of Standards, Washington, D. C.
William Good, Southern Johns-Manville Corp., Jarratt, Va.
Robert Hobbs, National Bureau of Standards, Washington, D. C.
John Symes, National Container Corp. of Va., Big Island, Va.

met in Richmond, Va., for the purpose of forming a paper industry technical group which will eventually become a Local Section of the Technical Association. Tentative arrangements were made for an organizational meeting to be held at the Jefferson Hotel in Richmond, Va., on Tuesday, Sept. 17, 1954. All individuals who may be interested to do so will be welcome to attend the first meeting of the group.

The temporary officers of the group are: chairman, John H. Symes; vice-chairman and program chairman, Robert B. Hobbs; treasurer, Julian Weaver; membership chairman, John J. Priest.

Wet Strength in Paper and Paperboard

TAPPI Monograph No. 13, "Wet Strength in Paper and Paperboard," was issued in May under the sponsorship of the TAPPI Wet Strength Committee.

This excellent publication includes chapters on raw materials, operating procedures for the manufacture of wet-strength papers, the chemistry of wet strength, process control, testing methods, and markets and uses of wet-strength papers.

The Association is indebted to the following individuals who collaborated in the preparation of the monograph.

K. W. Britt, chairman of the Wet Strength Committee, Scott Paper Co., Chester, Pa.
J. E. Donahue, Hercules Powder Co., Wilmington, Del.
R. P. Goodale, Rohm & Haas Co., Philadelphia, Pa.
I. J. Gruntfest, Rohm & Haas Co., Philadelphia, Pa.
L. E. Kelley, Rohm & Haas Co., Philadelphia, Pa.
C. S. Maxwell, American Cyanamid Co., Stamford, Conn.
J. P. Weidner, Container Corp. of America, Philadelphia, Pa.

Clarkson College of Technology

The alumni of the Clarkson College of Technology are planning to have a luncheon during the week of the 1955 annual meeting of TAPPI next February. Those interested in attending are requested to advise D. C. Mather, Carthage Paper Makers, Inc., Carthage, N. Y.

Fifth Coating Conference

The Fifth Coating Conference of the Technical Association of the Pulp and Paper Industry was held at the Poland Spring House, Poland Spring, Me., on May 24–26, 1954. The attendance of 455 delegates made this the largest coating conference to date. Delegates were present from 26 states as well as Canada, England, Sweden, Finland, and Brazil. Richard T. Trelfa, Watervliet Paper Co., Watervliet, Mich., is chairman of the sponsoring coating committee.

Chairman of the conference committee was J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me. Mr. Thomas was assisted by the following committee members: J. T. Loomer, Program, Robert Gair Co., Uncasville, Conn.; W. R. Willets, Exhibits, Titanium Pigment Corp., New York, N. Y.; C. G. Landes, Publicity, American Cyanamid Co., Stamford, Conn.; H. O. Ware, Panel, Hercules Powder Co., Wilmington, Del.; G. S. McKnight, Jr., Local Arrangements, Oxford Paper Co., Rumford, Me.; J. G. Bullard, Social, Corn Products Refining Co., Bennington, Vt.; R. C. Brown, Oxford Paper Co., Rumford, Me; J. E. Wilber, St. Regis Paper Co., Deferiet, N. Y.; F. N. Sprague, St. Regis Paper Co., Bucksport, Me.; A. C. Zettlemoyer, Lehigh University, Bethlehem, Pa.; J. H. Compton, Jr., Georgia Kaolin Co., Elizabeth, N. J.; H. L. Mellen, Hercules Powder Co., Holyoke, Mass., and A. D. Bonanno, Kelco Co., Andover, Mass.

The technical program, which was centered around the theme "New Techniques in Paper Coating Research," consisted of four technical sessions and a discussion panel featuring six outstanding research administrators in the paper coating field. The papers presented at the technical sessions are outlined briefly in the following account, and will be published in full in a future issue of *Tappi*.

Features of the conference also included the official banquet on Tuesday, May 25, a reception offered by suppliers to the coating industry, visits to the coating mills in the surrounding area, and exhibits of instruments and equipment of interest to coated paper manufacturers. A program was also provided for the many ladies who accompanied the delegates to the conference.

Technical Sessions

The conference was opened by the Coating Committee Chairman, R. T. Trelfa of Watervliet Paper Co., Watervliet, Mich. Mr. Trelfa welcomed the delegates to the conference on behalf of the TAPPI Coating Committee and turned the meeting over to J. J. Thomas, General Chairman of Conference Committee, who introduced the chairman of the first technical session, J. T. Loomer of Robert Gair Co., Uncasville, Conn.

Arnold J. McAneny, Bradner Smith Co., Chicago, Ill., presented a paper entitled "The Merchant Looks at the Coated Paper." In discussing the function of the paper merchant, Mr. McAneny discussed reasons why the coated paper market has grown so rapidly, and described some of the recent steps being taken to correlate papermaking variables with printing variables in the presses, plates, blankets, ink, and pressroom crew.

Emphasizing the importance of the human element in this problem, Mr. McAneny discussed the relation between the

The Coating Conference Committee: seated, J. T. Loomer, Robert Gair Co.; J. J. Thomas, S. D. Warren Co.; R. T. Trelfa, Watervliet Paper Co.; H. O. Ware, Hercules Powder Co.; A. J. Winchester, TAPPI. Standing, A. D. Bonanno, Kelco Co.; G. S. McKnight, Jr., Oxford Paper Co.; R. C. Brown, Oxford Paper Co.; J. G. Bullard, Corn Products Refining Co.; W. R. Willets, Titanium Pigment Corp.; and C. G. Landes, American Cyanamid Co.

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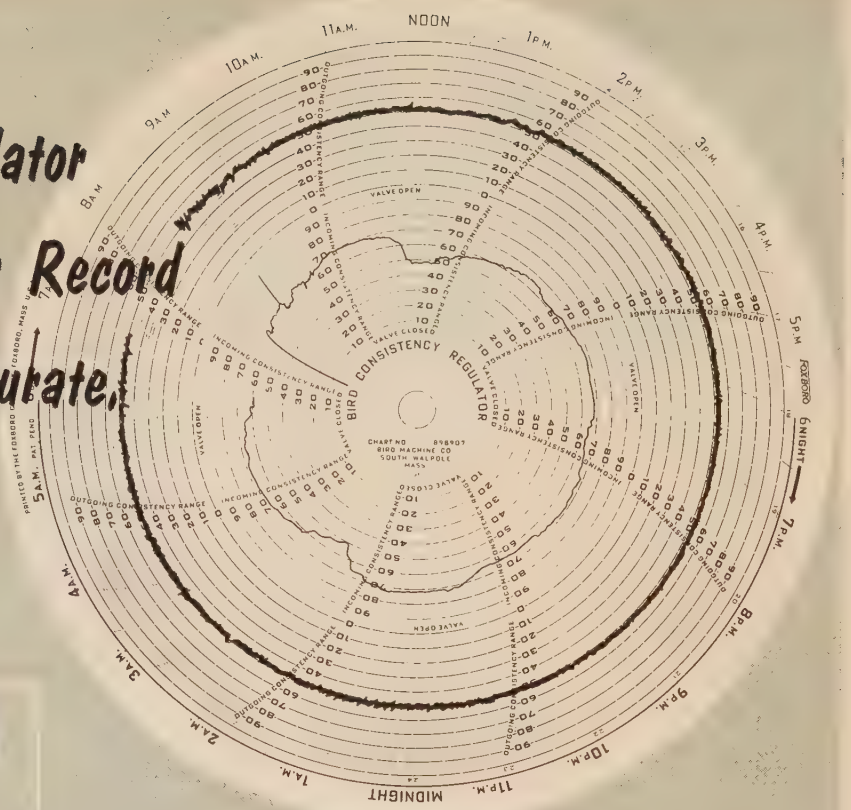

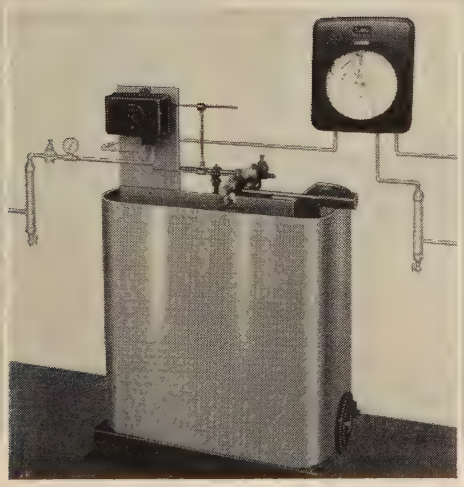

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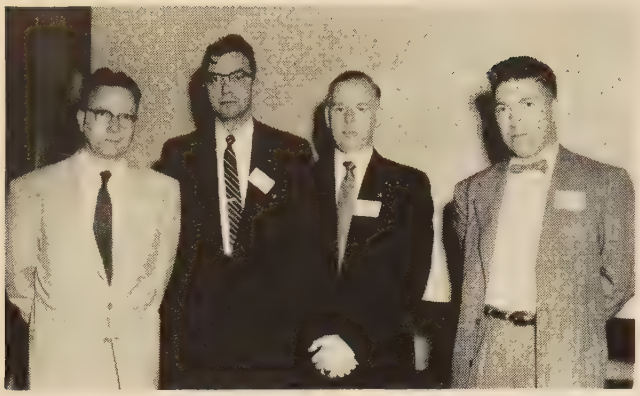

A. J. McAneny, Bradner Smith Co.; J. T. Loomer, Robert Gair Co.; W. D. Haskall, The Black-Clawson Co.; and L. W. Egan, Frank W. Egan & Co.

paper mill and the merchant. The technical man in the mill has all the training, education, papermaking know-how and experience necessary to make a fine sheet of paper but in many cases he cannot get his story across because a large percentage of printers are unable to talk his language or understand what he is trying to do. The merchant salesman on the other hand has many close contacts with papermill men and with the printer but is somewhat lost when technical problems arise. In closing his talk Mr. McAneny made a plea for closer cooperation between the paper mill man and the paper merchant and cited several case histories of successful cooperation.

"Coating Trends in Europe" was the subject of the second paper given by Lawrence W. Egan, Frank W. Egan & Company, Bound Brook, N. J. Mr. Egan gave recent per capita paper consumption figures for most European countries and compared them with those of the United States and Canada based on recent European tours made by members of his company. Mr. Egan discussed reasons for an anticipated increase in consumption of paper coating and referred to the trend from brush coaters to air coaters and to the increase in on-machine coating and to the rapid development of plastic coatings.

The third paper entitled "Waxed Papers—Production Methods and Equipment" by R. R. Eliker, Specialty Papers Co., Dayton, Ohio, and W. D. Haskell, Black-Clawson Co., Dilts Machine Division, Fulton, N. Y., was presented by Mr. Haskell. After giving a brief discussion of what is meant by waxed paper, Mr. Haskell stated that the ultimate purpose for which waxed paper is to be used usually determines the type and weight of the base paper and also the kind and amount of waxing to be applied.

Basically, waxed papers fall into four categories, namely: wet-waxed papers, dry-waxed papers, one-side waxed papers, and transparent waxed papers. A fifth category which Mr. Haskell covered briefly was wax-laminated papers.

Mr. Haskell then discussed the present market and consumption of waxed paper and the future trends in the waxed paper field.

Illustrating his talk with lantern slides, Mr. Haskell then went on to describe the equipment required for the production of papers in each of the four categories which he had discussed, with relation to the end product in each case. He also discussed production speeds, general widths, types of paper, waxed coating weights, and some of the problems involved in the production of each of these types of paper.

The author then described a single machine which is capable of producing all these grades and discussed its various features. In concluding Mr. Haskell discussed the high percentages of polyethylene used in wax, and discussed their effect upon the present day waxing machines and the wax paper market.

The afternoon session on May 24th was under the chairmanship of C. G. Landes of American Cyanamid Co., Stamford, Conn.

"An Approach to the Analysis of Synthetic Latex in Coated Papers" was the subject of the first paper by T. E. Dunfield and W. H. Watson, Polymer Corp., Sarnia, Ont., Canada. Mr. Watson, who presented this paper, stated that with the increasing use of synthetic rubber latex as a modifier or partial replacement for the more conventional coating color adhesives, it is natural that the question of analytical methods should arise. Mr. Watson described the early stages of an investigation regarding a semiquantitative precipitation identification of copolymerized styrene as found in a butadiene-styrene latex. The testing method developed is simple, rapid, and employs a minimum of laboratory equipment.

Although the scope of this method is not yet completely known, Mr. Watson stated that for internal mill testing where recipe details and appropriate latex styrene content are known a definite application exists. The work is continuing and it is expected that a quantitative determination will be developed in the near future.

Since the method is essentially the identification of the aromatic styrene structure, the analysis of papers of completely unknown composition will be hindered by the presence of any other ingredients involving aromatic hydrocarbon. Natural rubber having no aromatics gives a negative test. Mr. Watson also discussed the reaction of some other latex types.

The second paper of the Monday afternoon session was entitled "The Use of Dicyandiamide in Paper Coatings" by D. D. Ritson and C. G. Landes, American Cyanamid Co., Stamford, Conn. This paper was presented by Mr. Ritson who stated that dicyandiamide, or dicy, a nitrogen compound obtained from calcium cyanamide, has been used in the past primarily as an intermediate in the preparation of melamine, barbituric acid, and guanidine salts. More recently it has been found very useful for several different purposes in paper coating and adhesive fields. One of the principal uses of dicy in coatings has been to reduce viscosity of starch or protein dispersions and to improve their stability. Dicy is much more effective than urea in reducing the viscosity of numerous converted starch, dextrine, animal glue, and casein dispersions. In pigmented formulations dicy allows coating color solids to be raised without increasing viscosity and has been of considerable value for high solids machine coating. Mr. Ritson stated that dicyandiamide has also been used as an ingredient in fire retardent coatings for insulating board and acoustical tile. A small percentage of dicy in coating formulations

C. G. Landes, American Cyanamid Co.; L. M. Liggett, Wyandotte Chemicals Co.; D. D. Ritson, American Cyanamid Co.; R. N. Thompson, Calgon, Inc.; B. K. Asdell, Edgar Bros. Co.; and W. H. Watson, Polymer Corp.

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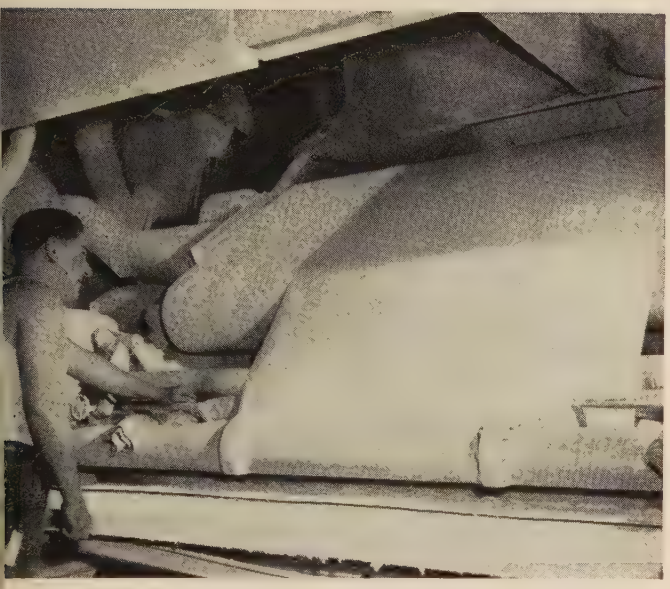

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You can also profit from many other advantages of "Elvanol." You get durable, flexible coatings that will take customary folds without cracking. You can increase coating flexibility, when needed, by using "Elvanol" plasticized with glycerine. And the "Elvanol" coatings can be made clear or pigmented with clay or titanium dioxide pigments.

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W. R. Willets, Titanium Pigment Corp.; W. V. Torrey, S. D. Warren Co.; F. Calvert, Drackett Products Co.; H. R. Hall, Allied Paper Mills; P. J. McLaughlin, Rohm & Haas Co.; D. L. MacAdam, Eastman Kodak Co.; and A. Glassman, R. R. Donnelley & Sons Co.

improves fire retardancy as evidenced by reduced char area and increased intumescence.

Ralph N. Thompson, Calgon, Inc., Pittsburgh, Pa., presented the following paper entitled "An Improved Method of Using Satin White," Mr. Thompson described a new concept of the structure of satin white and presented data showing the nature of the formation reaction. This concept postulates that satin white is a Werner-type complex held together by hydrogen bonding.

Mr. Thompson presented a new method of dispersing satin white by which it is possible to produce dispersions of unusual stability. The principal involved was that of coating the satin white with a protective colloid and dispersing the resultant mixture with a polyphosphate. The author stated that satin white treated by the process has a reduced adhesive demand and coating colors in which it is incorporated have improved fluidity.

"Precipitated Calcium Carbonates—Particle Size—Paper Coating Relationships" by T. E. Hall, Jr., P. McIntosh, L. M. Liggett, and R. W. Hagemeyer, Wyandotte Chemicals Co., Wyandotte, Mich., was the subject of the next paper. Mr. Liggett who presented it stated that coated paper properties and the rheological characteristics of the color are determined to a great extent by the particle size and shape of the pigments used. The author described a study of a series of precipitated calcium carbonates all made by a single commercial process and involving a range of particle size from 0.03 to 10 microns. All the members of the series would be considered as fine particle materials but the range here is greater than normally encountered in other coating pigments.

Mr. Liggett presented data showing the effect of particle size on adhesive requirement, visosity, gloss, and rheological properties in low solids coatings with several adhesive systems. The author concluded that the particle size required to give optimum value for the various coating properties is not always the same. The manufacturer must therefore select a particle size which is an intelligent compromise to obtain the most versatile product or make several products to meet special requirements.

Bernard K. Asdell, Edgar Brothers, McIntyre, Ga., presented the final paper of the Monday afternoon session, entitled "The Drying of Paper Coating Clays." Mr. Asdell presented a brief review of the drying mechanism of clay and described the common types of clay driers. The author showed that a close relationship exists between the final moisture content of clay and undispersed residue coarser than 15 microns. Experimental evidence showed that the undispersed residue comes largely from the surface of the drying clay as a result of surface shrinkage and the concentration and crystallization of residual salts. The formation of this "surface skin," Mr. Asdell stated, explains why lump coating clays are not usually dried to less than 5% moisture in conventional driers in a single stage. In spray driers the clay is atomized in the form of small spherical pellets which dry very rapidly while suspended in hot air out of all contact with hot metal surfaces. As a result of the rapid drying rate and very large surface development, spray-dried clay has very low undispersed residue and less than 1% moisture as compared to clay dried in other types of driers with high final moisture.

Photomicrographs of spray-dried clays were shown by Mr. Asdell, illustrating the spherical pellet-shaped particles with a mean size of approximately 175 microns. Because of this unique physical form, spray-dried clay has a bulk density comparable to lump clays and for most coating mill uses the make down is as good as pulverized clays which take up nearly twice the storage volume for unit weight. Spray drying is the only method known of drying clay to less than 1% moisture in a single stage without danger of overdrying.

On Tuesday, May 25, 1954, the morning session was under the chairmanship of W. R. Willets, Titanium Pigment Corp., New York, N. Y.

W. V. Torrey, S. D. Warren Co., Cumberland Mills, Me., presented a paper entitled "The Foaming of Coating Mixtures."

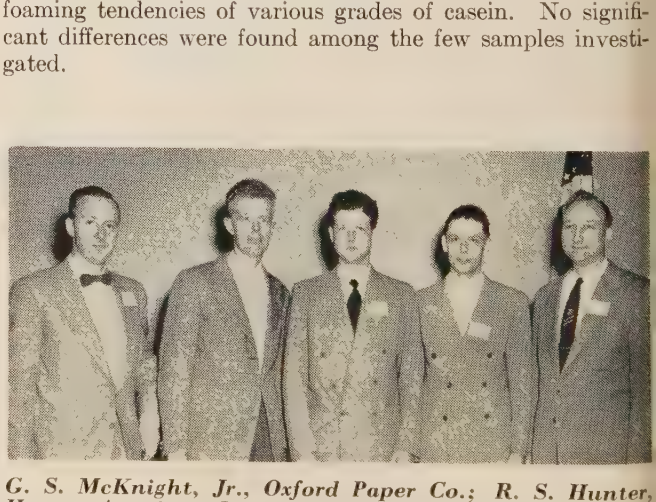
Mr. Torrey presented the results of approximately thirty-five years of investigational work into the problem of the foaming of coating mixtures carried out at the S. D. Warren Co.

A method of evaluating antifoam reagents, developed by the author, consists of magnifying the foaming tendency by subjecting aqueous coating mixture—with or without foam color—to violent agitation. Determination of the apparent specific gravity of the coatings before and after violent whipping yields results which can be calculated to a numerical basis. This method of evaluation has facilitated the investigation and adoption of several very efficient antifoam materials.

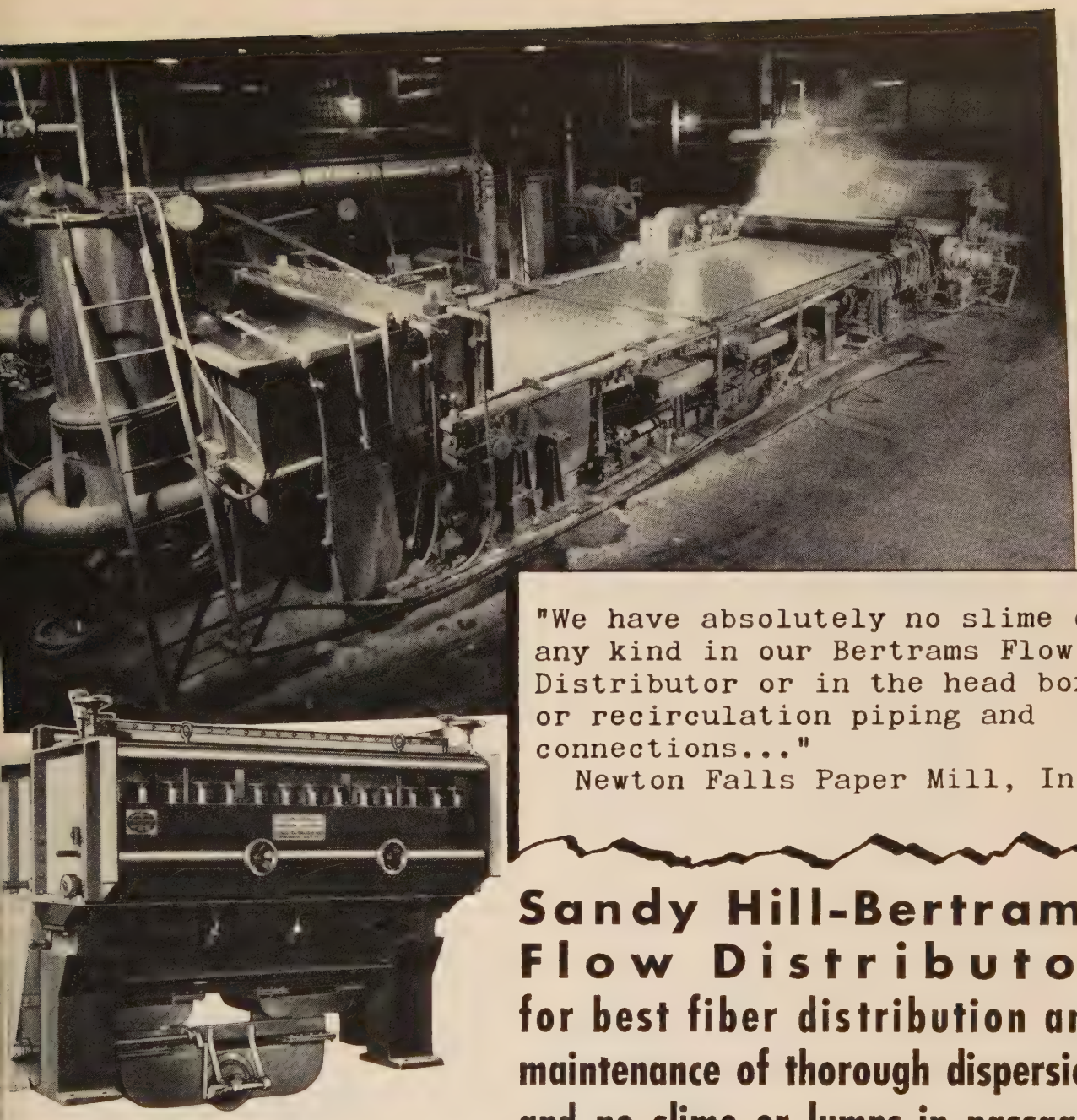
Materials proposed as foam killers vary in foam inhibiting potency from those which have no value to those which yield practically 100% inhibition of foam.

The author had studied the critical or threshold speed at which the revolving agitator just began to generate a significant amount of foam. It was found that the first appearance of a vortex and the first appearance of coarse foam occurred practically simultaneously.

Recently the author had begun a fragmentary study of foaming tendencies of various grades of casein. No significant differences were found among the few samples investigated.



G. S. McKnight, Jr., Oxford Paper Co.; R. S. Hunter, Hunter Associates Laboratory; H. J. Connell, S. D. Warren Co.; R. L. Clark, Mead Corp.; and J. W. Swanson, The Institute of Paper Chemistry



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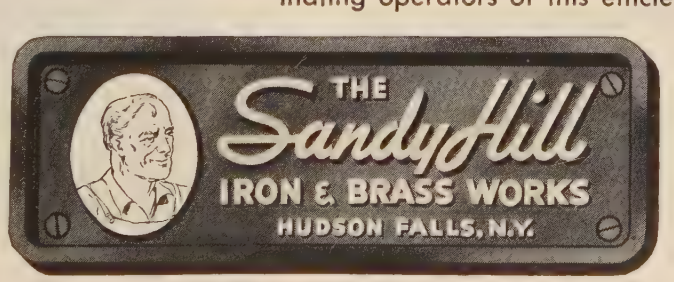

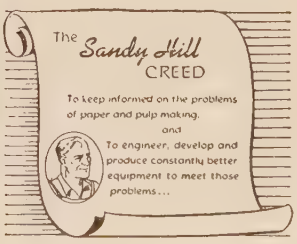
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and
To engineer, develop and produce constantly better equipment to meet those problems...

R. H. Savage, Mead Corp.; F. H. Frost, S. D. Warren Co.; G. K. Dickerman, Consolidated Water Power & Paper Co.; W. A. Kirkpatrick, Allied Paper Mills; G. Haywood, West Virginia Pulp & Paper Co.; P. J. Thoma, Time, Inc., and H. O. Ware, Hercules Powder Co.

Some of the conclusions of Mr. Torrey's studies on foaming phenomena are as follows: *a.* Foam in a coating mixture is an emulsion of air and water with the casein acting as the protective colloid or stabilizing agent; *b.* The tendency to foam is an inherent property of a coating mixture containing casein. Such a mixture will foam if subjected to a critical degree of mechanical agitation; *c.* Only a small amount of air can be emulsified in a coating employing starch as adhesive; *d.* It is impossible to emulsify air in a water suspension of an inorganic pigment, however, such a suspension plus a very small amount of casein—much less than necessary for adequate binding strength—will yield a large amount of foam upon violent agitation; *e.* a coating mixture can be stirred for an indefinite period without the generation of foam if the agitator speed is below the critical speed which produces a vortex; *f.* it is easier to modify the foaming tendency by adding antifoam reagent prior to agitating it than it is to break down the foam after it has been formed.

The second paper of the Tuesday morning session was presented by F. Calvert, Drackett Products Co., Cincinnati, Ohio, and was entitled "Recent Technological Developments in Industrial Soybean Proteins." Mr. Calvert presented a brief outline of the nature of proteins from the viewpoints of biological, chemical, and physical chemical characteristics, and discussed recent commercial developments in the manufacture and utilization of industrial soybean in proteins.

Mr. Calvert attributed the recent technological advances in industrial soybean proteins to a combination of fundamental theoretical laboratory research on proteins coupled with application of technological research in industry. The latter type of research has been carried out as a cooperative effort for many industrial formulators in their respective fields.

H. R. Hall, Allied Paper Mills, Kalamazoo, Mich., presented a paper on "The Use of Isolated Soybean Protein in Paper Coatings." Referring to the production of soybean protein, Mr. Hall stated that this product may be described as modified or unmodified according to the severity of the chemical treatment to which it has been subjected. The author then described the milder process by which unmodified soybean protein is produced.

Mr. Hall described and discussed the differences found in coating colors made from modified and unmodified soybean protein and explained that these differences are due to the presence of cysteine in the unmodified protein. The addition of sodium sulphite to unmodified protein, however, gives it properties similar to the modified protein.

Explaining that machine coating colors made with unmodified protein are dilatant when tested with the Hercules Hi-Shear Viscometer, Mr. Hall presented graphs showing how a second additive may overcome this tendency.

The author then compared papers coated with modified and unmodified protein and stated that these have equal brightness and finish but that the unmodified protein gives a slightly lower wax pick. The unmodified protein is cheaper but may require special formulas and techniques to produce results comparable to the modified protein.

"Evaluation of Acrylic Binders for Paper Coating Pigments by a Study of Free Films" was the subject of the next paper by P. J. McLaughlin, Rohm and Haas Co., Philadelphia, Pa.

Discussing the evaluation of binder requirements for various pigments for paper coatings, Mr. McLaughlin stated that the familiar wax pick test is dependent in a complex way on both the pigment binder and the binder paper adhesive. The author stated that this test is unreliable for synthetic thermoplastic binders and that the scotch tape adhesion test is sometimes used instead.

Mr. McLaughlin presented the results of a study based on free pigmented films considerably more massive than those normally applied to paper. In this way one factor in binder performance interaction with the substraight is eliminated and the study gave significant data on pigment binding efficiency and on the effects of dispersant and pigment composition on coating strength.

At any given level of binder the tensile strength of the free film may be taken as an inverse measure of the binder requirement of the pigment with Rhoplex AC-33 as binder at 10% on pigment and under comparable conditions of dispersion the author reported relative tensiles strengths as follows: HT clay 5; Lustra clay (88%–2 mu) 4.5; no. 34 English clay 3.3; 2 mu $CaCO_3$ 3.0; rutile 1.6; 0.2 mu $CaCO_3$ 1.0. Measured strength of the HT clay film was 250 p.s.i. Over the range 5 to 20% binder tensile strength was found proportional to binder level with strength increasing more rapidly for the coarser pigments.

The author described a technique for studying paper coating by observing free films 3 to 9 mils thick of identical composition dried on paper and on board from the same wet film thickness. This technique accentuates the effects of pigment, substrate, dispersant, and thickeners on separation of binder from pigment. Mr. McLaughlin reported that measurement of free film stiffness is a sensitive guide to the effect of binder on this property in coated paper.

"Color Measurement and Whiteness" by David L. MacAdam, Eastman Kodak Co., Rochester, N. Y. Mr. MacAdam pointed out that although the human eye is extremely sensitive to small differences in color, the human memory for color is short and faulty and the language of color is crude

R. T. Trelfa, P. J. Massey, and J. J. Thomas

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energy, rheological properties of the coating color, and receptivity of the raw stock.

R. L. Clark of the Mead Corp., Chillicothe, Ohio, then discussed "The Application of Photographic Techniques in the Evaluation of Surface Smoothness and Coverage of Coated Papers." The author began by defining surface smoothness and coverage which are recognized throughout the paper industry as two of the most important variables contributing to the printability of coated papers. Following this, Mr. Clark gave a brief discussion of the various evaluation tools and techniques which are useful in examining and assessing coverage in surface smoothness of coated papers, and then presented the merits and interpreted the value of phototechniques.

Phototechniques may be either photomacrographic or photomicrographic and the author gave illustrations of both and discussed how each may be used. Photomacrographic techniques are useful for illustrating the effects of coating weight, quality of raw stock, coating formulation, effects of calendering, mode of application, etc., and a coverage or surface smoothness. Mr. Clark stated that photomicrography, a more universally established technique, finds specific application in the study of coated constructions and may be used to study the quality of coverage and surface smoothness as a function of coating distribution, raw stock filler, fiber species, and refining.

The author described techniques and equipments essential to photomicrographic and photomacrographic applications and concluded his talk with a discussion of the ways in which these techniques can be used for research, technical service, sales service, and operations control.

The final paper of the afternoon session on May 25 was "Improved Methods for Testing Gloss" by Richard S. Hunter, Hunter Associates Laboratory, Falls Church, Va. Mr. Hunter described gloss as a consequence of the capacity of surfaces to reflect light in and near the specular angle being determined by the surface structure and composition. Gloss is as variable as are these factors. As there is no specific reflectance function which can be used for the gloss differentiation of all types of surfaces, Mr. Hunter stated that the best that can be done for practical routine measurements of gloss is to find for each different class of surface, the specific conditions of reflectance measurement which most closely reproduce the gloss ratings made visually.

New coating materials and techniques developed for paper and paperboard have recently provided surfaces that are glossier and different in appearance from those available previously. The author described the development of new instruments and techniques for measuring these new coatings and for improving upon the techniques applicable to traditional types of surface. These new instruments include:

1. A recording goniophotometer which gives a chart of the distribution of light reflected by a surface in different directions.
2. A multiangle gloss meter in which geometric conditions of measurement can be varied to select those best for the measurement of each type of material to be studied; accurate gloss measurements by previously standardized methods and new measurements not heretofore used can be made with this instrument.
3. New rotating slit electronic instruments which measure the distinctness of reflected inages rather than mere surface shininess.
4. A small spot surface uniformity gloss meter which measures the gloss uniformity of surfaces rather than their average gloss.

Mr. Hunter described each of these instruments and discussed its use in coating evaluation.

Panel

The Wednesday morning session was a panel discussion on the theme subject of the conference. H. O. Ware, Hercules Powder Co., Wilmington, Del., was chairman for the morning session.

The first panel speaker was Russell Savage, Vice-President and Technical Director of the Mead Corp., Chillicothe, Ohio, who spoke on the subject "Selling Research and Development to Management."

After defining the types of research: fundamental, applied, and development—Mr. Savage described the three stages through which a research department passes during its development and compared them with childhood, adolescence, and adulthood in the human being. The principal functions of research, Mr. Savage said are improvement of existing processes and products, development of new processes and products, and the effecting of savings in cost.

After discussing ways in which an effective research organization can be built up, Mr. Savage brought out some of the ways in which the research organization can enlist a support of management. One of the ways of achieving this objective is to have management itself choose and assign some of the problems of the research department. Another factor in achieving this end is effective reporting of research findings to management, and if a good job can be done in this regard, two thirds of the battle of selling research to management is won. The research department should be represented on the various planning committees of the organization, even including the board of directors. Mr. Savage stated that the research should insist on having a budget created and approved by management and should be careful to live within this budget.

In concluding Mr. Savage pointed out that because of the change in tax situation research is becoming more and more expensive and this presents a challenge to the research man to do a better job than ever before in selling himself to management.

"The Exploratory Research and Development Project" was the subject of the second talk by Gerald Haywood, Research Director, West Virginia Pulp & Paper Co., Luke, Md. Mr. Haywood stated that the prime purpose of an exploratory research project is to obtain information to determine whether or not the project is worth continuing. Suggested research problems may come from various parts of the organization such as management, sales service, production personnel, etc., and it is therefore important that a preliminary evaluation be made by means of an exploratory project.

Mr. Haywood then reviewed the steps necessary in approaching an exploratory project and emphasized that preliminary results must be reviewed with the orginator of the project before continuing to more advanced stages.

Gilbert Dickerman, Technical Director, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., then developed the subject further with a talk on "Research and Development on a Pilot Plant Scale." Mr. Dickerman discussed the various types and stages of pilot plant work. For example a pilot plant may consist of a small noncommercial, well-instrumented flexible arrangement, whose purpose is to determine quality of product, design details and costs, and which is also useful in training of future operators of commercial size equipment of the same type. A second type of pilot plant might consist of a single machine capable of producing sample rolls in sufficient quantity for use in testing and commercial evaluation. Such a machine might then be used in conjunction with an actual paper machine and operated as a prototype commercial unit.

"The Use of the Development Staff in Commercial Production" was the subject of the fourth member of the panel. William Kirkpatrick, Vice-President and Technical Director, Allied Paper Mills, Kalamazoo, Mich. Mr. Kirkpatrick expressed his belief that commercial scale development work should be carried out by practical development personnel rather than by research personnel. The development staff, he emphasized, should be staffed with men of practical experience and background familiar with machines and equipment and able to work well with mill operating personnel.

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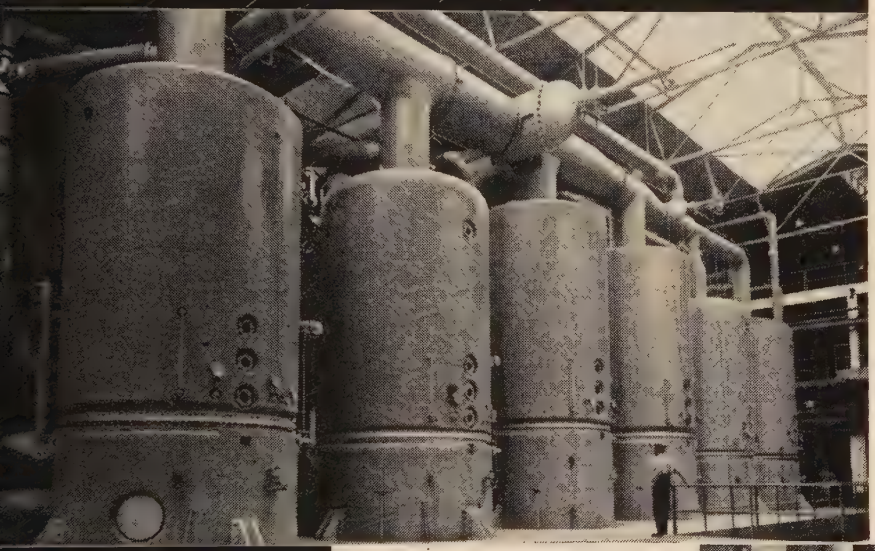

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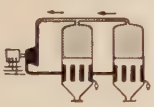

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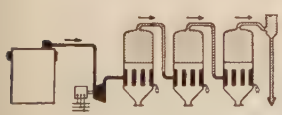

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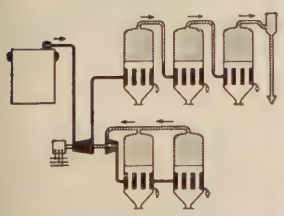

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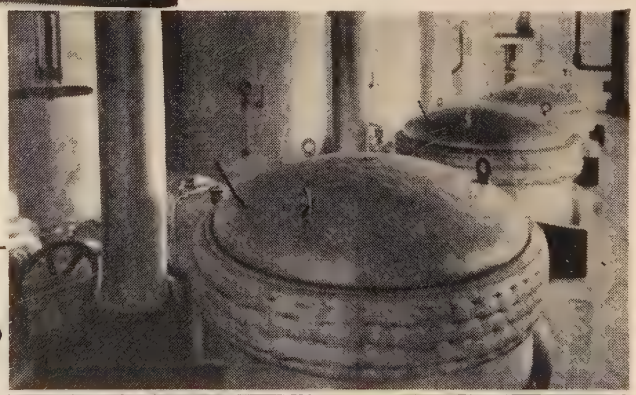

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They must be capable of maintaining a good relationship with management, labor, and production supervisory personnel. The development man must be capable of presenting a clear, concise report which, in Mr. Kirkpatrick's opinion, should be of a stereotyped nature under the traditional headings of subject, object, and conclusions.

The development group also performs another useful function in providing a reserve pool from which operating supervisory personnel may be drawn after their qualifications in handling labor have been observed. The development man, Mr. Kirkpatrick stated, should be thoroughly familar with end uses of the products of his company and should attend technical meetings in order to keep himself abreast of the latest developments in his field.

Frederick H. Frost, Vice-President in Charge of Research, S. D. Warren Co., Cumberland Mills, Me., then spoke on the subject of "Research and Development in Relation to Use Requirements." Mr. Frost discussed the position of the paper manufacturer as a middleman between the supplier of his raw materials and the ultimate purchaser of his finished product. Thus in his position as a "wholesaler" the paper manufacturer must have a profound knowledge of the requirements of his customer, the purchaser of his finished product. For example, if the purchaser of his product is a printer, he must study the printing process and must develop tests and testing methods to determine how his product will perform in the printer's hands.

The last panel speaker was Paul Thoma, Associate Director of Research, Time, Inc., Springdale, Conn., who discussed the subject "Paper Testing on Production Printing Equipment." In discussing the evaluation of the paper by observing its performance on the production press Mr. Thoma pointed out that pressroom difficulties may be caused by improper press operation as well as by paper defects, and that sometimes the paper is blamed when actually the press has been improperly operated. Because of this it is most important for the person investigating a pressroom difficulty to define his problem as accurately as possible in order to be sure that the trouble lies with the paper and not with the manner of operating the press or some other pressroom condition.

Following the panel talks, Chairman Ware opened the meeting to questions from the floor and a lively discussion period followed. In answer to a question as to how his company predicted pressroom performance on coated paper, Mr. Frost stated that they actually print the paper on commercial size presses. The printed samples are evaluated for half tone rating, ink absorbency, and drying time.

The panel was asked whether fundamental research should be carried out in industrial laboratories or whether it was a function of the colleges and universities. It was the opinion of the panel that fundamental research has no place in the industrial laboratories of an ordinary size company but some fundamental work should be done in the laboratories of the largest companies, and in actual fact some excellent fundamental work is going on now in such laboratories.

Referring to remarks made on report writing during his talk, Mr. Savage was asked whether he had found that there was a tendency for data to remain buried in the laboratory notebooks of the research workers. His reply was that this is very definitely the case and that possibly one way of overcoming it would be for the research man to write only brief summaries covering the salient points of his work.

In answer to a question regarding the possible financial returns from fundamental research, a panel member stated that it was impossible to predict such financial returns and that indeed this was not the purpose of fundamental research. However, the prediction of financial returns from applied research is both feasible and desirable.

In answer to a question regarding the origin of research problems, a member stated that problems should originate not only with management but also with the sales department, sales service department, operating department, and with the research department itself.

In relation to the connection between laboratory research and market research, a panel member replied that there should be a very close connection between the two and that considerable expenditures should be made on market research before any money is spent on laboratory research.

The question was raised as to how research department personnel should be kept acquainted with the problems of the production and sales departments. It was suggested that the best means of doing this is to have frequent meetings between the personnel of the research, sales, and production departments.

In response to a question as to what percentage of the sales

Fifth Coating Conference banquet, May 25, 1954

G. Bullard, G. S. McKnight, Jr., Mrs. Bonanno, A. J. Winchester, H. O. Ware, Mrs. Bullard, J. H. Heuer

H. O. Ware, Mrs. Bullard, J. H. Heuer, Mrs. Loomer, A. D. Bonanno, Mrs. Trelfa, W. W. Holland

llar should be spent on research, individuals suggested from
to 1% as a fair figure for the paper industry. One
eaker felt that the amount spent by the paper industry
ould be gradually increased to bring it in line with the 3 to
% being spent by the other chemical industries, but these
creased expenditures should not be made until the paper
mpanies are set up to spend the money effectively.

In regard to the role of universities and consultants in
aper research the panel members agreed that fundamental
search should be carried out in the university laboratory
d that consultants can perform an extremely useful func-
on in supplying specialized assistance to both small and
rger organizations.

The question was raised as to how long a new product should
guided by the research department before management
kes over. Mr. Kirkpatrick stated that in his view the
chnical staff should maintain complete control until the
oduct had proved itself commercially acceptable and until
e process is operating satisfactorily.

Mr. Thoma was asked what he considered to be the most
portant way in which research could improve the quality
printing papers. He replied that in his view the most im-
rtant need is for better uniformity.

The question was raised as to how the small organization
ould go about setting up a research department. It was
ggested that a one- or two-machine mill should confine
self to technical service and control work or to a limited
mber of projects of such a nature that their value could be
sily demonstrated to management.

There was some discussion as to how research projects
ould be initiated or discontinued. In this connection Mr.
rost described a screening committee setup that has worked
ell at the S. D. Warren Co. This committee was established
pass on projects relating to new product development. It
nsists of three men from each of manufacturing, research,
d sales. Mr. Frost stated that this arrangement had sub-
antially increased a number of projects brought to a suc-
ssful conclusion.

nquet

The official banquet of the Fifth Coating Conference was
ld on Tuesday evening, May 25. The four previous coat-
g conferences have each featured an address by an out-
anding leader in the paper industry, and this year's address
as scheduled to be given by Rex W. Hovey, Executive
ce-President of the Oxford Paper Co., Rumford, Me. Mr.
ovey, however, was prevented by illness from attending the
nference, and his address on the theme subject of the con-
rence was presented by Walter W. Holland, Mill Manager
of the Oxford Paper Co. at Rumford. The full text of Mr. Hovey's talk is published elsewhere in this issue of *Tappi*.

The master of ceremonies was J. J. Thomas, General Chairman of the Coating Conference, who introduced the individuals seated at the head table and then called upon Richard T. Trelfa, Coating Committee Chairman. Mr. Trelfa paid tribute, on behalf of friends in the coating field, to Edwin Sutermeister for his achievements in paper coating technology, and presented Mr. Sutermeister with an engraved silver tray.

Following this, Mr. Trelfa thanked John H. Heuer, Great Northern Paper Co., Millinocket, Me., for his past service as chairman of the coating committee, and presented him with a rifle on behalf of members of the committee.

Mill Visits

On Wednesday afternoon, May 26, over two hundred delegates visited the mill of the S. D. Warren Co. at Cumberland Mills, Me. This tour featured conversion coating operations but also included some machine coating. Other parts of the mill were also available for inspection, and the delegates were particularly impressed with the new modern three-stage bleach plant with its control lab separated from the operating floor by a ceiling-to-floor glass panel. In addition to this operation the S. D. Warren Co. also bleaches 60 tons of pine pulp in a single-stage hypochlorite system. Also of a particular interest was the extensive commercial size printing shop used by the Warren Co. in the evaluation of its papers.

On Thursday, May 27, close to one hundred delegates visited the mills of the Oxford Paper Co. at Rumford, Me. Of particular interest here was the Kimberly-Clark-Mead coating press operating on no. 12 machine at 1280 f.p.m. on 43 lb. coated text. This machine, with a $163^1/_2$-in. wire, produces 121 tons of 43-lb. text per day. It is driven by a G.E. electronic drive, and features moisture control by means of Brown moisturegraphs.

The visitors also showed considerable interest in the color plant with its pneumatic system for handling clay. This system, built by the Fuller Co., can handle up to $7^1/_2$ tons of clay per hour. Also of interest were the three new 10-roll Appleton supercalenders, 154 in. wide. Two of these operate at speeds up to 1550 f.p.m., the third having a maximum speed of 2000 f.p.m.

Also on May 27, about fifty delegates visited the Bucksport, Me., mill of St. Regis Paper Co. A feature of this visit was the machine coating utilizing high solids coating color prepared by the Vanderbilt system. The delegates also observed the sulphite and groundwood mills with their continuous peroxide bleaching and the wood storage handling and cleaning facilities. The St. Regis Paper Co. entertained the visitors at luncheon.

. W. Holland, J. J. Thomas, Mrs. Holland, Edwin Sutermeister, R. T. Trelfa, Mrs. Thomas, P. J. Massey

P. J. Massey, Mrs. McKnight, J. D. Davis, Mrs. Willets, J. T. Loomer, W. R. Willets, R. T. Bingham

The DRAPER Felt
DRAPER BROTHERS COMPANY
CANTON, MASS.

Ladies' Program

A program for the ladies present was arranged by a committee consisting of Mrs. James Bullard, chairman, Mrs. George McKnight, Mrs. Joseph Thomas, and Mrs. Alfred Bonanno.

On Sunday evening, May 23, a get-acquainted card party was held under Mrs. George McKnight. The men were also invited to attend this party at which several tables of bridge and hearts were enjoyed. First prize for hearts went to William O'Neil. Mrs. L. Crouse took the high score at bridge with Mrs. H. Hall, second. Men's high at bridge went to Ken Grace and H. Watson, who tied for the top score.

On Monday morning and Tuesday afternoon, the ladies held a putting competition. First prize for this event went to Mrs. S. Chase, second prize to Mrs. C. Kesler.

The ladies also got together on Monday afternoon for a card and scrabble party. The door prize on this occasion went to Mrs. Claude Bos, and Mrs. W. J. Barrett won the scrabble contest. First prize at bridge went to Mrs. A. Lamoureux, second prize to Mrs. Richard Trelfa.

On Tuesday morning, May 25, the ladies visited the Bates Manufacturing Co., in Lewiston, Me., where they observed the manufacture of a variety of cotton goods.

Exhibits

A feature at this coating conference was an exhibit of color preparation, coating, laboratory, and auxiliary equipment which was viewed by a large number of interested persons.

Mrs. G. S. McKnight, Jr., Mrs. J. G. Bullard, Mrs. J. J. Thomas, and Mrs. A. D. Bonanno, the Ladies' Program Committee

Ample space had been provided by the hotel and time was allotted by the program comittee for demonstration.

Several of the firms represented showed mixers for color preparation of various designs ranging from commercial or pilot plant sizes to laboratory units. Included were the Abbe Engineering Co., New York, N. Y., Brookfield Engineering Laboratories, Stoughton, Mass.; The Cowles Co., Inc., Cayuga, N. Y.; Kinetic Dispersion Corp., Buffalo, N. Y.; Morehouse Industries, Atlanta, Ga.; and Read Standard Co., York, Pa. The Henry Pratt Co. of Chicago, Ill., demonstrated the continuous starch cooker which was developed by Penick & Ford, Ltd.

In the field of coating units the John Waldron Corp., New Brunswick, N. J., had a coater and an embosser set up while the Dilts Machine Works Div. of The Black-Clawson Co., Fulton, N. Y., and Frank W. Egan & Co., Bound Brook, N. J., showed movies of their units.

Auxiliary equipment included such items as controls by Fischer & Porter Co., Hatboro, Pa.; General Electric Co., Schenectady, N. Y.; Minneapolis-Honeywell Regulator Co., Boston, Mass.; Chaus Scale Corp., Union, N. J., and pumps by Robbins & Myers, Inc., Springfield, Ohio. The Chromium Corp. of America had an exhibit showing chromium plating of rolls and the Radiant Heater Div. of Edwin L. Wiegand Co., Pittsburgh, Pa., had a panel illustrating the use of their electric strip heaters.

Since it was a coating conference, it was natural that viscometers would be included and representatives were present from the Brookfield Engineering Laboratories, Martinson Machine Co., Kalamazoo, Mich., and Norcross Corp., Newton, Mass.

Those interested in the optical characteristics of coated papers had the opportunity to visit those with Hunter Associates Laboratory, Falls Church, Va., and the Macbeth Corp., of Newburgh, N. Y.

W. & L. E. Gurley, Troy, N. Y.; the Sheffield Corp., Dayton, Ohio, and the Thwing-Albert Instrument Co., Philadelphia, Pa., had smoothness, porosity, and other instruments of interest to paper coaters on display.

Of late there has been considerable interest in pick testing and arrangements were made to have several different types available for inspection through the courtesy of the National Printing Ink Research Institute located at Bethlehem, Pa.

Also of current interest, both to the coater and the printer, is determination of the amount of moisture in a sheet and the Hart-Moisture-Meters, New York, N. Y., had representatives present to explain their apparatus.

Through the courtesy of these exhibitors there was ample opportunity for those attending the Fifth Coating Conference to discuss the many varied aspects which pertain to the coating of paper and so acquire current knowledge of the most up-to-date developments.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Kenneth G. Aitken, Technical Service Representative, anadian Industries Ltd., Montreal, P. Q., Canada, a 1947 raduate of McGill University.

Marcel G. Alarie, Mill Chemist, Richmond Pulp & Paper of anada Ltd., Bromptonville, P. Q., Canada, a 1950 graduate f the Paper Chemistry School.

Johannes Albrecht, Director of Research, Deutsche Gesellchaft für Forschung im Graphischen Gewerbe eV., Munchen ermany, a 1925 graduate of the Technical University with a h.D. degree.

Allan Asbury, Chief Engineer, The English Electric Co. td., Stafford, England, a 1938 graduate of Birmingham niversity.

Louis O. Barber, General Superintendent, Minerva Wax aper Co., Minerva, Ohio.

Burleigh E. Barnes, Production Supervisor, S. D. Warren o., Cumberland Mills, Me., a 1951 graduate of Bowdoin Colge.

John E. Boyle, Consultant, Booz, Allen & Hamilton, New ork, N. Y., a 1932 graduate of the University of Toronto.

Robert M. Brown, Chemist, Howard Paper Mills, Inc., Dayn, Ohio, a 1950 graduate of North Carolina State College.

James D. Casey, Plant Superintendent, Robert Gair Co., nc., Ohio Corrugated Box Div., Cleveland, Ohio.

Cleora Clanton, Librarian, Dallas Public Library, Dallas, ex.

Joseph Collingwood, Chief Inspector, Doeskin Products, nc., New York, N. Y., a 1950 graduate of the University of lassachusetts.

Carl J. Combs, Quality Control Supervisor, American Coatg Mills Div., Robert Gair Co., Inc., Middletown, Ohio.

Lowell T. Crews, Group Leader, Standard Oil Co. (Ind.), esearch Laboratory, Whiting, Ind., a 1939 graduate of Oklaoma A & M College.

Gosta R. W. Dahl, General Manager and Technical Director, iplasto S. A., Ramallo, Buenos Aires, Argentina, a 1924 raduate of the Technical University, Helsingfors.

Thomas C. Davidson, Paper Mill Manager, Buckland Paper ills, Dover, Kent, England, a 1927 graduate of Edinburgh niversity.

Lloyd P. Ellison, Sales Engineer, The Black-Clawson Co., artle Bros. Machine Div., Middletown, Ohio, a 1948 gradate of Tri-State College.

Gustaf L. Erikson, Executive Vice-President, The Braden tphin Ink Co., Cleveland, Ohio.

Jose V. Ferrara, Assistant Technical Director, Fabrica de apel "Monterrey" S. A., Monterrey, N. L. Mexico, a 1952 aduate of the University of Dayton.

Par Gierow, Assistant to the President, Jonkopings Mekanka Werkstads A. B., Jonkopings, Sweden, a 1922 graduate The Royal Institute of Technology, Stockholm.

Basil S. Goerner, Student, New York State College of orestry, Syracuse, N. Y.

Katsuni Hata, Assistant Professor, Kagawa Agricultural ollege, Kagawa-ken, Japan, a 1946 graduate of Kyoto Unirsity.

John G. Hoad, Owner, John G. Hoad & Associates, Ann rbor, Mich., a 1932 graduate of University of Michigan, Colge of Engineering.

Stanley W. Hoyman, Draftsman-Engineer, Central States Engineering, Inc., Appleton, Wis., a 1947 graduate of Indiana Technical College, Fort Wayne.

Gunji Ishikawa, Director, Fuji Library, Chuo-ku, Tokyo, Japan, a graduate of the Japan Military University.

Charles E. Jakeway, Manager, Technical Dept., American Box Board Co., Grand Rapids, Mich., a 1941 graduate of Michigan State College.

Robert D. Johnson, Packaging Engineer, Owen-Illinois Glass Co., Toledo, Ohio, a 1930 graduate of Shurtleff College with a Ph.D. degree.

David A. Jonah, Librarian, Brown University Library, Providence, R. I., a 1929 graduate of Allison University.

Robert M. Joos, Salesman, Cochrane Corp., Philadelphia, Pa., a 1946 graduate of the University of Pennsylvania.

Charles Klucker, Sales Representative, Anheuser-Busch, Inc., St. Louis, Mo.

F. Michael Languedoc, Technical Representative, Canadian Industries Ltd., Specialities Dept., Toronto, Ont., Canada, a 1949 graduate of McGill University.

Wallace M. Larlee, Salesman, Stein, Hall & Co., Inc., New York, N. Y., 1945 graduate of Mount Alison College.

Charles E. LaValley, Superintendent, J. & J. Rogers Co., Au Sable Forks, N. Y.

Jose C. O. Leone, Technical Adviser, Banco Nacional do Desenvolvimento Economics, Rio de Janiero, Brazil, a 1948 graduate of Ecola Nacional de Quimica.

William V. McLeod, Bleach Plant Foreman, Hollingsworth & Whitney, Mobile, Ala., a 1948 graduate of Mississippi State College.

William J. Miller, Technical Control Superintendent, Canadian International Paper Co., Gatineau, P. Q., Canada, a 1937 graduate of the University of New Brunswick.

Guy M. Minard, Vice-President and Manager, Spruce Falls Power & Paper Co. Ltd., Kapuskasing, Ont., Canada, a 1928 graduate of Queen's University.

John C. Moessinger, Jr., Electrical Engineer, International Paper Co., Ticonderoga, N. Y., a 1950 graduate of Union College.

Michael J. Moriarty, Chemist, Cupples-Hesse Corp., St. Louis, Mo., a 1949 graduate of St. Louis University.

Robert D. Morse, Plant Engineer, Consolidated Paper Co., Monroe, Mich., a 1940 graduate of the University of Michigan.

Junichi Nagata, Professor, Utsunomiya University, Utsunomiya, Japan, a 1932 graduate of Tokyo University.

Nagakazu Nakamura, Head, Third Research Section, Arakawa Rinsan Kagaku Goshi Kaisah, Jyoto-ku, Osaka, Japan, a 1919 graduate of Meiji College of Technology.

Vernon S. Nicholl, General Manager, Secretary and Treasurer, Modern Hard Chrome Service Co., Camden, N. J.

Koichi Oiwa, Head of Research, Noguchi Research Institute, Tokyo, Japan, a 1935 graduate of Hokkaido Imperial University.

Carl D. Perkins, Student, University of Maine, Orono, Me. (graduated on June 20, 1954).

Daniele P. Pigna, Cartiere Paolo Pigna S.P.A., Alzano Lombardo, Bergamo, Italy.

Richard N. Plow, Technical Director, A. O. Reynolds Co., Lebanon, Ind., a 1918 graduate of Yale University.

John V. Rosequist, Chemist, Eastman Kodak Co., Rochester, N. Y., a 1943 graduate of Northeastern University.

Max Rutishauser, Chief Chemist, Cellulosefabrik Attisholz

A.-G., Attisholz, Switzerland, a 1940 graduate of the Technical University, Zurich.

Hans A. Salzer, Technical Manager, Matth. Salzer Sons, Stattersdorf, Austria, a 1908 graduate of the Technical University.

William C. Schultz, Assistant Manager, Consumer Relations, West Virginia Pulp & Paper Co., Mechanicville, N. Y., a 1942 graduate of Rensselaer Polytechnic Institute.

Lloyd D. Shand, Sales Representative, Monsanto Chemical Co., Cleveland, Ohio, a 1939 graduate of Tufts College.

Bruce W. Smith, Technical Representative, Isotope Products Ltd., Oakville, Ont., Canada, a 1951 graduate of McMaster University.

Robert J. Solari, Research Collaborator, Forest Products Laboratory, Madison, Wis., a 1947 graduate of Massachusetts Institute of Technology.

Joseph Tankard, Head of Testing Dept., British Rayon Research Association, Manchester, England, a 1935 graduate of Manchester University.

John E. S. Tasman, Chief Chemist, Columbia Cellulose Co. Ltd., Prince Rupert, B. C., Canada, a 1942 graduate of Dalhousie University.

Robert Thomann, Vice-President, Pump and Blower Div., Sulzer Brothers Ltd., Winterthur, Switzerland, a 1925 graduate of Lausanne University.

Rex A. Thorne, Chemical Engineer, Union Bag & Paper Corp., Chicago, Ill., a 1950 graduate of Purdue University.

U. Saw Tun, Secretary, Paper Factory & Chemical Industries Board, and Deputy Director of Industries, Rangoon, Burma, a 1946 graduate of Yale University.

Janet Vernon, Technical Librarian, Minnesota Mining & Manufacturing Co., St. Paul, Minn., a 1939 graduate of the University of Illinois.

John T. Walton, Resident Manager, National Container Corp. of Ohio, Jaite, Ohio, a 1948 graduate of Kent State University.

Frederick H. Wagman, Director of Library, University of Michigan, Ann Arbor, Mich., a 1942 graduate of Columbia University with a Ph.D. degree.

Bjarne S. Wiborg, Chemical Engineer, Rena Kartonfabrik A/S, Rena, Norway, a 1954 graduate of the University of Durham, England, with a Ph.D. degree.

Clarke B. Williams, Student, New York State College of Forestry, Syracuse, N. Y.

Harry T. Wohlers, Salesman, American Cyanamid Co., Pigments Div., New York, N. Y., a 1940 graduate of Polytechnic Institute of Brooklyn.

Harry R. Wortham, Assistant Manager, Fibre Div., Archer-Daniels-Midland Co., Minneapolis, Minn., a 1943 graduate of the University of Minnesota.

Barbara H. Wortley, Chemist, Solvay Process Div., Syracuse, N. Y., a 1948 graduate of the New York State College of Forestry.

TAPPI Notes

Warren E. Abrams is now an Industrial Engineer for the Hudson Pulp & Paper Co., New York, N. Y.

Gerald F. Alcorn is now Chief Construction Engineer for the Weyerhaeuser Timber Co., Pulp Div., Longview, Wash.

Henry J. Allison, Jr. of the Container Corp. of America has been transferred from Chicago, Ill., to Fernandina, Beach, Fla., as Technical Director.

Arthur Aronoff, formerly of the APW Products Co., Inc., is now Chief Chemist for the Smith Paper Div., Peter J. Schweitzer, Inc., Lee, Mass.

E. H. Barclay, formerly of the Union Bag & Paper Corp., is now Design Engineer for the St. Regis Paper Co., Cantonment, Fla.

Walter J. Brand is now Assistant Director of Research for the Westfield River Paper Co., Russell, Mass.

O. M. Cornell, Salesman for the American Cyanamid Co., has been transferred from New York City to Portland, Ore.

Paul B. Corning is now Resident Engineer in Charge of Construction for the Lowe Paper Co., Ridgefield, N. J.

Joseph E. Cotter, formerly Assistant Manager of Cartonajes Estrella S/A, is now a Paper and Paperboard Mill Consultant in Mexico City.

Thage Dahlgren is now Manager of the Paper Div. of the Pioneer Chemical Co., Philadelphia, Pa.

Francis L. Fennell of the Pyroxygen Products Dept. of E. I. du Pont de Nemours & Co., Inc. has been transferred from Niagara Falls, N. Y., to Wilmington, Del.

Francis W. Flynn of the Crown Zellerbach Corp. has been transferred from Camas, Wash., to Port Townsend, Wash., as Assistant Manager.

John H. Freymeyer, formerly of the Ohio Boxboard Co., is now Chemist for the Atlanta Paper Co., Atlanta, Ga.

Allen H. Gridley, formerly of the National Container Corp., is now Engineer for the Great Northern Paper Co., Millinocket, Me.

John R. Guilliams of the Chemical Div., Goodyear Tire & Rubber Co., has been transferred from Hartford, Conn., to La Mesa, Calif.

Robert W. Hagemeyer is now Product Manager of Calcium Carbonate Sales for the Michigan Alkali Div., Wyandotte Chemicals Corp.

M. Leon Hamilton is now General Supervisor of the Combining Operations at the Ogden Ave. Div. of Container Corp. of America, Chicago, Ill.

Wilbur M. Hayes, formerly of Curtin & Riley, is now Civil Engineer of the U. S. Corps of Engineers, Boston, Mass.

Manne H. Helgegren, formerly of Foster-Wheeler Corp., is now Engineer for the International Paper Co., Palmer, N. Y.

Sydney W. Hooper, formerly of Hydraulic Machinery Co. Ltd., is now President of S. W. Hooper Co. Ltd., Montreal, P. Q.

David C. Howard, formerly of the American Coating Mills, is now Technical Director of The Ace Folding Box Co., White Pigeon, Mich.

Bernard C. Johnson is now Pulp Mill Superintendent of the Detroit Sulphite Pulp & Paper Co., Detroit, Mich.

Gunnar Kulvik, formerly of Ouler Oy, is now with Enso-Gutzeit Oy, Kotka, Finland.

Edwin R. Littmann of the Enjay Co., Inc. has been transferred from Elizabeth, N. J., to New York City.

A. J. Luettgen is now Mill Manager of P. H. Glatfelter Co., Spring Grove, Pa.

Eugene F. McCarty, formerly of the Nekoosa-Edwards Paper Co., is now in the Research Dept. of Bemis Bros. Bag Co., Minneapolis, Minn.

James H. McClure, formerly Vice-President of the Industrial Container & Paper Corp., is now with W. C. Ritchie & Co., Chicago, Ill.

John D. S. Macdonald is now Technical Assistant to the General Paper Mill Superintendent, Canada Paper Co., Windsor, P. Q.

John N. McGovern, formerly of the Forest Products Laboratory, is now Process Engineer for Parsons & Whittemore, Inc., New York, N. Y.

Felix A. Mariani, formerly of the Modena Paper Mills, Inc., is now Technical Director of the Chesapeake Paperboard Co., Baltimore, Md.

John D. Moore is now Assistant Superintendent of the Pulp Mill, Oswego Falls Corp., Fulton, N. Y.

A. G. Natwick is now Resident Manager of the East Texas Pulp & Paper Co., Silsbee, Tex.

John W. Natwick is now Sales Engineer for Jackson & Church Co., Saginaw, Mich.

John J. Osmer, formerly of Osmer Chemical Processes, Inc., is now Research Chemist for the Chicopee Mfg. Co., Milltown, N. J.

Donald K. Pattilloch is now a Consulting Engineer at 52 Gramercy Park North, New York, N. Y.

Joseph C. Pullman is now Assistant to the Manager of the New Product Development Dept. of American Cyanamid Co., New York, N. Y.

Gustaf Ranhagen, formerly of the Swedish Cellulose Co., is now Project Engineer for A/B Celleco, Uppsala, Sweden.

Glen T. Renegar is now Mill Manager of the Container Corp. of America, Philadelphia, Pa.

Roy D. Rivers, formerly of Ballapur Paper and Strawboard Mills, is now Technical Adviser to John Inglis Co. Ltd., Toronto, Ont.

O. Walter Rodowski is now Pulp Mill Superintendent for the P. McBare Paper Co., Roaring Spring, Pa.

Roland O. H. Runkel is now Chief of the Wood and Cellulose Chemistry Section of Bundenstalt für Forst-und Holzuirschaft, Reinbek, Hamburg, Germany.

William E. Soles is now Vice-President of the Anglo-Canadian Pulp & Paper Mills Ltd., Quebec, P. Q.

Conrad Steen is now Sulphite-Groundwood Superintendent of Embretsfos Paper Mills, Amot-Modum, Norway.

R. Casper Swaney, formerly of the Mountain State Fabricating Co., is now President and Treasurer of the Hot Oil Heater Co., Inc., Carlisle, Pa.

James R. Wellman of the American Cyanamid Co. has been transferred from Kalamazoo, Mich., to Chicago, Ill., as Director of the Paper Chemicals Application Laboratory.

Frederick Wierk is now associated as an Engineer with the Consulting Architects and Engineers firm of Reynolds, Smith & Hills, Jacksonville, Fla.

* * *

William Gilbert, Purchasing Agent, has succeeded *G. M. Gilbert* (retired) as the official corporate representative of the Gilbert Paper Co., Menasha, Wis., in the Technical Association.

* * *

O. V. Tally, Director of Industrial Sales, has succeeded F. L. Manly as the official representative of the Allis-Chalmers Mfg. Co., Milwaukee, Wis., in TAPPI.

Industry Notes

Production

The production of paper and paperboard in March is estimated to have been 2,287,000 tons. Although the output of individual segments, particularly building paper and board and paperboard, was below their 1953 levels for the same month, operations by the balance of the industry were of such proportions that total production was slightly in excess of that at in March, 1953. Industry output for the first 3 months amounted to 6,493,231 tons, 1.2 and 3.4% less than for the same period in 1953 and 1951, respectively, and 5.0% more than in 1952. Production has for most of the major groups been in excess of new orders received but in March, for the first time since last September, the total volume of orders received exceeded output.

Pulpwood

Receipts of pulpwood for the first two months of this year were 4,781,000 cords, 67,000 cords above receipts for the comparable months last year. Domestic receipts increased by 1,000 cords and imports by 6000 cords.

Pulpwood consumption for January and February totaled 5,577,000 cords, 63,000 more than for the same months in 1953. Regionally, the Northeast, Appalachian, and Lake States showed declines in consumption ranging from 4 to 7% while the South and Pacific Northwest registered increases of from 3 to 11%.

Inventories at the end of February were 5,834,000 cords, an increase of 195,000 cords over inventories at the end of January, but 299,000 cords less than at the end of February, 1953. In comparison to inventories at the end of February last year, inventories in the Northeast, Lake States, and Pacific Northwest Regions showed declines ranging from 6 to 13%, while inventories in the South and Appalachian regions increased 12 and 21%, respectively.

Wood Pulp

February wood pulp production totaled 1,370,000 tons, an increase of 28,000 tons over February, 1953. For the first two months of this year, production totaled 2,861,000 tons—48,000 tons above the comparable months last year.

Consumption of wood pulp was lower in both January and February of this year than in comparison to the same months last year. The total consumption for the two months this year was 2,983,000 tons, a decline of 20,000 tons from last year.

Exports of wood pulp for the first two months of this year were 37,000 tons, almost twice as large as the 19,000 tons reported during the same period in 1953.

Imports of wood pulp for January and February totaled 316,239 tons, a decline of 44,330 tons from the level of imports for the comparable 1953 months. Imports from overseas declined sharply from 121,456 to 72,876 tons while imports from Canada showed a moderate increase, from 239,113 to 243,363 tons.

Wood pulp inventories at the end of February were 652,000 tons, an increase of 8000 tons over inventories at the end of January, but 50,000 tons less than inventories at the end of February, 1953. Inventories at pulp mills at the end of February this year were 154,000 tons, and at paper and board mills, 498,000 tons.

Production and shipments of newsprint in North America during April, 1954, amounted to 590,038 tons—an all-time April high—and to 592,260 tons respectively, compared with corresponding totals of 568,510 and 587,893 tons in the same month of 1953. Output in the United States was 89,839 tons and shipments were 88,968 tons while Canadian (including Newfoundland), production amounted to 500,199 tons—the peak April record to date–and shipments totaled 503,292 tons.

Through the end of April this year United States mills turned out 15,649 tons or 4.4% more newsprint than in the first four months of 1953 while output in Canada also was 72,360 tons or 3.9% greater than in the corresponding period of last year; thus the total continental increase amounted to 88,009 tons or 3.9%.

North American manufacturers' stocks on April 30, 1954 aggregated 195,531 tons compared with 197,753 tons on the last day of the preceding month and 191,160 tons at the end of April 1953. The continental total was composed of 9,557 tons and 185,974 tons held by United States and Canadian mills respectively and inventories were higher than a year ago by 1670 tons in the former instance and by 2701 tons in the latter.

Paper and Paperboard

Paper and paperboard continue to register output at about the same levels as a year ago at the peak of the boom. In the week ended May 15, capacity operations in paper mills were at 94.2%, slightly under last year, but about equal in tonnage output on the basis of a larger capacity. Paperboard production that week was 14% ahead of last year's 251,473 tons.

Nation's business identifies paper as the "third fastest growing industry." Nearly 500 companies maintain 700 plants in 38 states of the union. The total production of paper and paper products in 1953 was a record 26,556,356 tons, 9% ahead of 1952. American use of paper, about 60% of the world's total, is about 391 lb. per capita. This com-

pares to Canada's 250 lb. per capita, and to China (where paper was invented) of 1 lb. per capita per year.

Wastepaper

Mill receipts of wastepaper for the entire United States during the first quarter of this year aggregated 1,966,983 tons, a drop of 5% from the receipts of 2,075,231 tons in the first three months of 1953.

National wastepaper consumption in this year's first quarter dropped 6%, the 1954 consumption being 2,002,867 tons as against 2,131,600 tons in the first three months of 1953.

Consumption of wastepaper by the nation's paperboard mills in the first quarter of this year totaled 1,516,849 tons as against a consumption of 1,653,372 tons in the comparable quarter a year ago, a decrease of 8.2%.

On the other hand, there was an increase of 2.7% in the consumption of wastepaper by the nation's paper mills during the first quarter of this year as compared with the like period of 1953. The first quarter consumption this year by paper mills was 290,194 tons as against 282,542 in 1953.

Building materials mills of the United States during the first quarter of this year consumed more wastepaper than during the first three months of last year as well as the first quarter of 1952. Only in 1951, when wastepaper consumption was at its all-time peak, did the manufacturers of construction materials buy and consume more wastepaper in a year's first quarter.

The manufacturers of the building materials are those engaged in making roofing, sidings, wallboards, building paper, insulation, etc. There are some 16 such mills in the Eastern area, of which 14 consume the mixed grades of wastepaper, 10 the news grades, and nine old corrugated. Within the last year or so there has been a substantial increase in the tonnage of old corrugated consumed by the roofing mills.

Total consumption of all grades of wastepaper by the paper mills, paperboard mills, wet machine board mills, and the building materials mills during the first quarter of this year dropped 6% from the first quarter of last year. Consumption by the paper mills increased 2.7%; consumption by the paperboard mills decreased 8.2%, but consumption by the building materials mills increased 7% over the first quarter of 1953 and 10.2% over the first quarter of 1952.

Wastepaper consumption by the construction materials mills for the first quarter of the last four years follows: 1954, 174,903 tons; 1953, 163,322 tons; 1952, 158,640 tons; 1951, 196,729 tons.

Total consumption of building papers in the United States last year amounted to 1,312,311 tons, an average of 16.4 lb. per capita. Total consumption of building boards amounted to 1,402,369 tons, an average of 17.5 lb. per capita. The total tonnage of wastepaper consumed by the mills producing these materials amounted to 769,148 tons, an average of 10 lb. per capita.

TV Fire Detection

New eyes in Louisiana's forest fire detection system look out from plexiglas domes atop the fire towers. The eyes are those of television cameras which continually scan the surrounding area and transmit the picture to a receiver in a central control station 50 miles away. An operator at the control station sees the fire appear on the picture tube together with an azimuth reading picked up by the camera from markings on the dome. By noting the azimuth reading of the same fire pictured from another tower a cross-out can be obtained, giving the exact location of the fire.

While only preliminary tests of the "detecto-vision" system have been made, State Forester James E. Mixon sees possibilities for it in the very near future. Another application of the system would be to spot woods arsonists in the act of setting fires.

Oregon

Tree farm acreage in Oregon has climbed past the 3,000,000-acre mark.

W. D. Hagenstein, manager of the Industrial Forestry Assn., and E. L. Kolbe, forester for the Western Pine Assn., announced jointly Oregon's tree farm register had reached 124 holdings totaling 3,008,284 acres. These groups sponsor the tree farm program in western and eastern Oregon, respectively.

Of western states, only Washington has more certified tree farms than Oregon, according to recent figures compiled by American Forest Products Industries, Inc., national sponsors. Washington, which originated the tree farm movement in 1941, has 214 holdings totaling 3,195,405 acres.

West Virginia

Tree planting machines can be used effectively to reforest approximately one tenth of the 200,000 acres needing planting in a ten-county area in West Virginia, according to an estimate of the Upper Monongahela Valley Assn. The association's tree planter, one of the first in the state was used to plant 77,550 trees and shrubs in its first season of operation. This amounted to about one tenth of the total of all trees planted in the area.

The use of tree planting machines in West Virginia is limited by the steep terrain. Only about five are in use at the present time.

Purchasing Directory

The first complete guide to military and civilian purchasing activities of the Federal Government is now available from the Superintendent of Documents in Washington for 50 cents. This directory lists some 4000 classes of commodities covering more than 5,000,000 items purchased by both the military and civilian agencies.

U.K.

Britain still is unable to afford unrestricted imports of newsprint, Derek Heathcoat Amory, Minister of State for the Board of Trade, told the House of Commons recently.

Newspaper representatives have said that it may be possible to remove statutory control over distribution of newsprint next year if an additional 100,000 tons could be imported, he explained. However, they did not suggest that this would be sufficient to meet unrestricted consumption, he added.

The minister revealed that 50,000 tons had been authorized for importation from Canada, but that as far as nondollar newsprint was concerned, he had been informed that no additional supplies would be available this year.

Argentina

If there were no restrictions, Argentina today would probably import about 200,000 tons of newsprint a year, but under the present system of controls Argentina has to make do with from 60,000 to 70,000 tons a year, according to a market survey in *Unionnytt*, organ of the Norwegian papermaking Union Co.

Argentina's own newsprint production is only about 33,000 tons a year, so that the country must for a long time continue to be a major importer of newsprint. For other types of paper, imports are dwindling steadily owing to the constantly increasing production in Argentina.

Germany

For the first time since the war major quantities of Czech newsprint for West German printers are passing through Furth im Walde, one of the main German stations on the Czech-Bavarian frontier. The exact tonnage of these exports is not known.

Russia

Taking a long-term view, the growth of Russia's pulp production is spectacular. In 1913, Russian domestic pulp output was at 408,000 tons, and 107,000 tons had to be imported. The estimated Soviet pulp production in 1953 was 2,300,000 tons.

There are at present 90 cellulose-producing plants in the Soviet Union, some of them with an annual productive capacity in the region of 100,000 tons. While the most important plants are situated in Karelia and the Arkhangelsk region where spruce and fir, supplying resinous wood, are as abundant as in Canada, there are also a few factories in Central Russia, in the Ural mountains, in the Caucasus, and in Siberia. Some of the pulping plants are making use of reeds and straw, in particular in regions where conifers are not easily available.

At present Soviet official quarters complain that there are bottlenecks in the supply of the pulping plants with raw materials and that only 88% of their total capacity was exploited in 1953.

Mexico

The Mexican Government has announced that the following paper items are exempted, effective April 20, from the general 15% increase in duties instituted Feb. 15, 1954; paper, white, or dyed for cigarettes, in sheets or rolls over 4 cm. in width, without printing; paper of the natural color of the pulp, for cigarettes, in sheets or rolls over 4 cm. in width, without printing; paper cut in strips up to 4 cm. in width, for cigarettes, without printing; paper cut in strips up to 4 cm. in width, for cigarettes, with printing and glassine paper weighing up to 50 grams per square meter.

Saltcake

Recent increases in the price of saltcake appear to be caused by the fact that sodium sulphate is produced as a by-product of rayon, phenol, and chrome. Automobile manufacturers are not taking chrome as fast as previously, rayon manufacture has slowed down, and facilities have been cut back. These facts plus the falling off of overseas imports and increased consumption for sulphate pulping have combined to bring about an increase in price.

Tall Oil

Tall oils are mixtures of fatty acids and rosin acids in combination with small amounts of unsaponifiable substances. Crude or whole tall oil is produced by splitting, with sulphuric acid, the skimmings—sodium salts of the rosin and fatty acids—produced when pinewood is chemically pulped by the kraft sulphate process.

Originating as they do in widely separated areas of the country, these crude tall oils vary in composition:

Fatty acids—30–35% (broken down, these are oleic, 45–50%; linoleic, 45–50%; palmitic, 5–7%).
Rosin acids—35–60% (abietic, 30–40%; neoabietic, 10–20%).
Unsaponifiables—5–10% (beta-sitosterol, 25–30%).

This combination is highly desirable for such uses as soaps, emulsifiers, paint driers, and drying oils of all types. It is not too unsaturated for many soap products, yet not too saturated for many paints and varnishes.

And, in order to suit a particular demand, the whole tall oil can be processed further to improve its color, odor, and to change its composition. The ratio of fatty to rosin acids can be varied widely, usually in favor of higher fatty acid concentrations, to a point where the tall oil, as such, ceases to exist, giving way to substantially pure fatty and rosin fractions.

Some refiners use acid purification processes—whole tall oil treated with concentrated sulphuric and impurities removed as an acid sludge. This gives a product practically unchanged in fatty and rosin acid composition in yields of 85–90%. Others use distillation methods to give products of varying composition in yields of approximately 75%.

Facts and Figures

Tall oils have experienced rapid growth in just a few years but their future promises even more room for expansion. Let's look at some figures:

Domestic consumption—up nearly one third in 1953 over 1948: 283 million lb. vs. 214 million lb. Add to this exports now running about 40 million lb. a year.

Total inedible fats and oils market—tall oils ranked fourth in 1953, surpassed only by tallow, linseed oil, and coconut oil. They contributed more than 7% of the fats and oils used for nonfood end products (a 3.5 billion lb. market last year).

Drying Oils Market

Tall oils ranked third in 1953 (only linseed and soybean oils were ahead), contributing 7% of the 1 billion lb. of fats and oils consumed for this purpose. They also placed fourth—behind linseed, soybean, and tung oils—in paint and varnish jobs. About 31% of all tall oil consumption goes to the drying oil field: 5, 5, 11, and 10% going to linoleum, resins, paint, varnish, and miscellaneous, respectively.

Whole Oil to Refined Oil Ratios. Production of refined and distilled grades ran about 27% of all tall oil produced; their sales constituted about 30% of all tall oil sold.

Availability. Source of all tall oils—the kraft paper industry—has really been tearing along in recent years: 5 million tons of pulp in 1948, 8 million in 1953. Translated in terms of tall oil potential these figures mean that tall oil available from pulp in 1948 was 350 million lb., in 1953, 560 million lb. (One ton of pulp yields about 70 lb. of crude oil.) Thus tall oil production will not be squeezed at the source for some time.

Price. Two words, stable and low, describe tall oil prices. In 1949 refined tall oil was 5.4¢ per lb.; in. 1953, 5.0¢ per lb., with only small fluctuations in between. Cost of crude tall oil as of March, 1954, was $40 a ton. Some grades cost 1 to 2¢ per lb. more, depending upon the degree of refinement. Other fats and oil prices wavered much more sharply in the same period.

Reasons for Demand

Tall oils are finding favor, and here are the reasons why: they are low in price, available in a free market, have a large and steady domestic source of supply, and are chemically versatile. To date there are no government regulations on their marketing or price; tall oils are not associated with food products.

Low Stable Cost. Whole tall oil is the lowest priced organic acid in the world. Unlike most industrial oils, tall oil is not related to edibles; its prices are not influenced by food shortages and price support programs. Pulp mills, anxious to develop such an enormous potential by-product, value their skimmings at a comparatively low figure. With this low cost raw material as a basis, tall oils may be refined to many grades, priced quite low compared to other fats and oils and to rosin, all of which are quite costly to collect and bring together for processing.

Good Supply. There are no crop failures to vary the availability of tall oils.

Tall oils are products of the paper industry, which is very stable and growing. Further expansion in kraft pulping is expected to add 20% to its present capacity, and to tall oil capacity, in the next three or four years. Tall oil supplies may be further augmented by greater efficiency in their recovery from pulp waste liquor.

Since the paper industry uses much costly equipment

that must be operated around the clock to be profitable, manufacturers of tall oils can work just as steadily.

Fatty Acids

The fatty acids in tall oils react chemically in typical fashion. They form water-soluble soaps with alkalies, ammonia, and amines and water insolubles, oil-soluble soaps with heavy metal salts. Esters are produced by heating with monohydric or polyhydric alcohols, while amides are formed by heating the amine salts. Reduction of the alkyl esters with sodium produces a mixture of unsaturated alcohols, while high pressure hydrogenations yield saturated alcohols. Reaction with ethylene oxide yields condensation products valuable as detergents.

The double bonds in linoleic acid are responsible for such properties as air drying of tall oil fatty acid esters, reactions with maleic anhydride and styrene, polymerization and bodying by heat or air blowing. The ethylenic linkages of both oleic and linoleic acid allow sulphonation with sulphuric acid. Reaction with sulphur gives polymeric products cross linked with sulphur atoms. Unsaturated acids are converted to saturated acids by catalytic hydrogenation; limited amounts of hydrogen will yield a product consisting mainly of oleic acid.

The linoleic acid content brings tall oil fatty acids into the range of semidrying fatty acids used in medium and long chain oil alkyds. The nearly complete absence of linolenic acid accounts for the nonyellowing properties so valuable in white baking enamels.

Esters with polyfunctional alcohols, such as pentaerythritol and polypentaerythritol, have fair drying and good film properties, which can be improved by maleation, styrenation, and condensation with phenolic resins.

Rosin Acids

Although many of the reactions of the rosin acids are similar to those already claimed for the fatty acids, a few others should be mentioned: reaction of the rosin acids with lime or zinc oxide produces higher melting oil and solvent-soluble salts used in varnishes and printing inks. Salts of lead, manganese, and cobalt are useful as driers. A major use for the sodium salt is in sizing paper.

The double bonds in the rosin acids take part in a number of reactions: hydrogenation, polymerization, and condensation with maleic anhydride. The latter reaction yields a product which can be further treated with a polyhydric alcohol to produce high melting resins compatible with nitrocellulose and useful in furniture lacquers and sanding sealers. The sodium salt of the original condensation product also is a superior paper sizer.

Unsaponifiables

Of chief interest in the small fraction is beta-sitosterol which has been used to synthesize sex hormones and other biological compounds. Lately there has been considerable interest in the use of this compound as a possible starting material for the synthesis of cortical steroids, such as cortisone.

Special Advantages

Tall oils, containing both rosins and fatty acids, behave similarly to other sources of these products. The obvious question is: why use them at all? Low cost is, of course, a big reason. But there are other advantages which several industries are exploiting.

Soaps. Since saponification can be effected merely by mixing tall oils with various bases, very simple equipment is required. This is a distinct advantage over natural fats and oil which require boiling for saponification and salting out to separate the soap from the glycerol and excess alkali. This should appeal to small soapmakers and those in the chemical specialities field.

Sodium soaps of tall oil are more water soluble than those of the more saturated fatty acids, like tallow and coconut oil, particularly at low temperatures. In some cases you can substitute sodium soaps for those of potassium with a double-barreled saving: low cost fatty acid and low cost alkali.

And tall oil soaps are less viscous as a rule. They can be blended with more saturated fatty acids and used as dispersants in oil emulsions to give better stability and surface activity. When expensive alkalies such as triethanolamine or morpholine are used, the low acid numbers of tall oils offer savings of 10% or more.

Emulsions. A number of soluble oil manufacturers favor tall oil soaps as emulsifiers because of their high oil solubility. Insecticidal emulsions of DDT, chlordane, and toxaphene are being prepared with tall oil emulsifiers. Also, considerable amounts of tall oil go into making cutting oils—both clear and emulsion types—and into asphalt emulsions.

Paint Driers. These agents are generally metal-organo compounds; the metal catalyzes drying time, the organic portion solubilizes the metal in the coating. Until recently only naphthenates and ethyl hexoates have been suitable. But talates—salts of tall oil acids and drying metals—are replacing them because of their lower cost and greater solubility.

And these properties can be improved by aldehyde pretreatment. A lower acid number results, causing greater quantities of the metal to react with the same amount of oil.

Drying Oil. Limed tall oils act as gloss oils in interior paints. However their substitution for about 25% of linseed oil is said to be practical in many outdoor paints with little sacrifice in their useful life.

Tall oil esters are superior to limed oils in water and alkali resistance and film toughness. The rosin esters—hard solids—are added to drying oils to improve dried film hardness. Tall oil as a source of rosin acids is much more convenient to handle than the solid rosins.

Modified Alkyds. Tall oils are used as modifiers in the production of alkyd resins to control cross linkage and at the same time impart desirable qualities of solubility, gloss, and flexibility. Superior in these respects to straight oil modified alkyds, the tall oil resins cost substantially less: high alkyd viscosities are achieved with less phthalic anhydride—a pentaerythritol tall oil alkyd of 18 to 20% phthalic has the same viscosity as a 28% phthalic, oil-modified PTE alkyd with no decrease in stability.

More Recent Developments

Tall oil reacts with epoxy resins, too, to give superior quick-drying varnishes without the addition of more expensive, fast-drying oils. Tall oil cyclopentadiene condensation products are reported to be soluble in drying oils as well as in usual paint solvents, thus affording glycerin economy.

And tall oils have been styrenated and then esterified with a number of polyalcohols. Varnishes made in this manner from a 62% fatty acid tall oil and tripentaerythritol give fast drying films of excellent flexibility, good brushability and water resistance.

—from *Chemical Engineering*, June, 1954.

MULTIWALL BAGS

Over 75% of bakery flour is packed in multiwall bags today as compared with less than 10% ten years ago. In the feed industry, more than 25% of the annual manufactured feed production is packaged in easy to handle 50-lb. multiwall bags as compared with 97% packaged in 100-lb. cotton or burlap bags in 1949.

PACKAGING COURSE

The Packaging Training Program for 1955 is announced in

booklet published by the Joint Military Packaging Course, ossford Ordnance Depot, Toledo 1, Ohio.

low Does Your Company Rate?

Does your company place a reasonable percentage of its nnual profits in a company foundation chartered to make haritable gifts?

Does a top executive or responsible committee carefully udy the agencies, hospitals, colleges, and other organizaons within your larger community and recommend gift alocations upon the basis of considered policy? Or does your ompany merely wait to be asked and then grease the squeakst wheels?

How much does your company know about its employees' milies and its stockholders, their college affiliations, use of ospitals, YM-YWCA, Boy or Girl Scouts, and other conections that may deserve company support?

Does your company demand an immediate concrete return r every gift, or does it recognize that some deserving activies have long-range effects upon the community or our entire ociety?

Does your company follow through on its gifts to see how ie money is used so that a decision can be made to eliminate, ntinue, or enlarge its contribution next year?

How many of your company family are responsible officers trustees of agencies being aided?

Is your company making its contribution merely because ost of it goes to reduce the corporate income tax, or because really believes in free-enterprise business supporting the her free enterprises in our democracy?

Are you proud of being a good-neighbor corporate citizen, do you give reluctantly, under pressure?

nnual Reporting

The annual report has become a thing of beauty and a joy r printers. Gone are the days when corporation presidents mply sent out a terse mimeograph stating that the company rned so much last year compared with so much the previous ear. It may or may not have contained the rousing assurnce that "if all goes well, we hope to maintain the current vidend rate." Today it takes a CPA to tell what a comny made after reserves, amortization, taxes, and countless arts, graphs and "candid" pictures of executives looking sy and employees looking happy.

Preparation of the report calls for the joint efforts of the dvertising Dept., Publicity Dept., Public Relations Dept., les Dept., New Business Dept., Old Business Dept., and ny expendable vice-presidents not specifically engaged in ie company's main business, that of making and selling idgets. Designed primarily as a promotion piece, and hang ie expense, it may even win a Honorable Mention, Class C ward, along with a dozen other companies in the same field.

The most complicated, and dullest, part of any report is ie president's message. It must strike exactly the right alance between optimism and conservatism. If things apear to be going too smoothly, stockholders may get the nthinkable idea that the management is overpaid. If ifficulties are overstressed, they may deduce that the job too big for present incumbents.

The best course is to treat so casually or so technically of ompany affairs that no one can figure out what happened. closing, be sure to come out strongly against communism nd high taxes. This shows a firm grasp of the foreign situaon as well as of domestic problems.

Of course, only two people will ever read the great opus all rough: (a) an assistant statistician in some brokerage firm,) Old Man Smithers, age 83, who owns ten shares of stock. he latter will also attend the annual meeting and make is traditional speech criticizing the company's dividend olicy and its lack of foresight back in 1902 when it failed to uy out Henry Ford.

Jot It Down

Wise men with bad memories jot down the thoughts that occur to them; wise men with good memories do the same. They do not put too heavy a burden on a good servant. Charles Darwin jotted down new facts that conflicted with his own views—those were the things he was most likely to forget. Thomas Hobbes, the philosopher, carried a staff on his walks. In its head, ink and a pencil were hidden. Jonathan Edwards, American philosopher, pinned notes to his coat when he went out riding. Note-taking catches the flying thought before it vanishes. Jot it down. It may be the idea that can change the shape of your future.

FPBAA

Lehigh University, Bethlehem, Pa., has undertaken a contract with the Folding Paper Box Association of America for a research project involving applied and fundamental studies pertaining to the measurement of printability of boxboard.

On behalf of the Folding Paper Box Association President William H. Walters, The U. S. Printing & Lithograph Co., has appointed a special task committee to direct this research project on the printability of folding boxboard. The members of this committee include F. D. Long, Container Corp. of America, Chicago, as chairman; Gordon Dalsemer, The Lord Baltimore Press, Inc., Baltimore, Md.; and W. W. Fitzhugh, Jr., William W. Fitzhugh, Inc., Brooklyn, N. Y. Martin Galbraith, Sutherland Paper Co., Kalamazoo, Mich., who is serving as chairman of the Association's Research and Technical Committee, is an *ex-officio* member of this group.

Some of the objectives of the study include the devising of standard procedures using existing, modified, or newly designed instruments to make possible predictable results in the printing of folding cartons and to test for printing smoothness and ink receptivity.

Hercules

Hercules Powder Co.'s continuous process for producing chemical grade cotton from linters has been in operation at Hopewell, Va., since 1949, and is now operating on a 300-ton per day basis.

The unique feature of the process is that digestion is carried out on moist cotton fibers rather than fibers slurried in liquor. The fibrous solids are fed continuously by a feeder which forms a moving plug to seal pressure inside the digester.

Advantages claimed for the Hercules process over the batch process are: greater uniformity, better quality, somewhat higher yields, lower operating cost, and smaller space requirements.

It is also claimed that the stream pollution problem may be easier to overcome with the continuous process, because the waste liquor has a high solids content that should make its recovery economically feasible.

The new process also provides flexibility of operation, conditions being readily varied to produce various grades of cellulose.

Hammermill

New bleach and pulping facilities will be constructed for the Hammermill Paper Co. at Erie, Pa., by The Rust Engineering Co. Cost of the project is around $3,500,000.

Pennsylvania

The Department of Forests and Water of Pennsylvania has published report no. 2 of the Forest and Water Research Project of the Delaware Lehigh Experimental Forest.

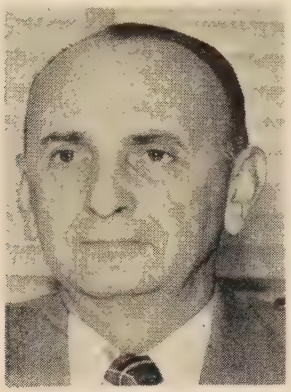
Missisquoi

W. E. Smiddy, Jr. has been appointed general sales manager

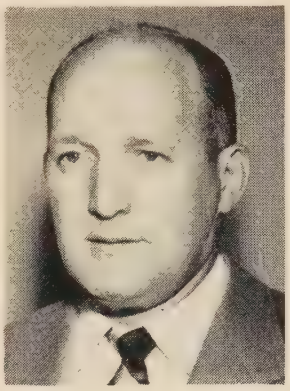
of the Missisquoi corp., Sheldon Springs, Vt. Mr. Smiddy's office is at 551 5th Ave., New York, N. Y.

GLATFELTER

A. J. Luettgen has been appointed mill manager, and L. B. Owen, general superintendent of the P. H. Glatfelter Co.,



A. J. Luettgen, P. H. Glatfelter Co.



L. B. Owen, P. H. Glatfelter Co.

Spring Grove, Pa. Stewart C. Burns has been appointed superintendent of finishing.

NATIONAL VULCANIZED FIBER

National Vulcanized Fiber Co., Wilmington, Del., has announced a formation of an advertising-promotion department as part of a long-range company expansion program.

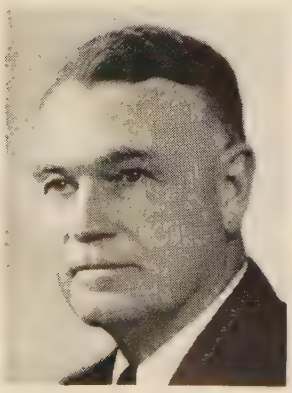
SCOTT

The Scott Paper Co. has authorized the installation of two additional high-speed paper machines at its Everett, Wash., mill. These two machines, the third and fourth to be installed at Everett, will go into operation in 1955, and will necessitate the construction of another building similar to that now housing existing equipment. In addition, stock preparation equipment and machinery essential to the finishing and shipping of the complete line of Scott products will be included in the construction schedule.

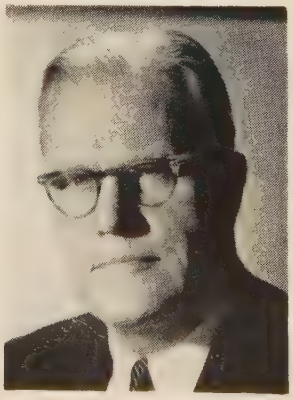
I.P.

John H. Hinman has been elected chairman of the board of International Paper Co., New York, N. Y., and Richard C. Doane has been elected president and general sales manager. I.P. has recently acquired the outstanding stock of American Exports, Inc., whose operations will be integrated with those of the I.P. sales department.

A new multiwall sack plant will be opened by I.P. at Mobile, Ala., this month. The new 50,000-sq. ft. plant will manufacture multiwall paper shipping sacks and asphalt laminated papers. Senior personnel will include S. D. Andrew, plant manager, C. B. McCord, assistant plant manager, and Asa Morgan, superintendent.



J. H. Hinman, International Paper Co.



R. C. Doane, International Paper Co.

CONSOLIDATED

A new building filled with storage tanks and carloading equipment is a recent development in the increased use of spent sulphite liquor developed by Interlake Mill of Consolidated Water Power & Paper Co., Appleton, Wis.

A structure 92 by 36 ft. has been completed for storage and loading. Inside, three tanks with capacity of 33,000 gal. each receive concentrated liquor as it comes from the mill's half-million-dollar evaporator plant. Each tank holds approximately one day's output of the evaporators, and the three thus can accommodate the concentrate produced in the evaporator plant during a long weekend when the rest of the mill shuts down. Loading docks have facilities for simultaneously filling a railroad tank car and tank trucks.

B. C.'s FIRST PAPER MILL

"It was quite an experience," according to several people who helped build, and worked in, the first paper mill in British Columbia. It was the mill of the British Columbia Paper Manufacturing Co. on the Stamp River a few miles north of Port Alberni.

It was a short-lived operation. It started in late 1894 and folded in early 1896. The entire staff numbered twelve, four of whom were Mrs. Morrisson of Alberni, George Bird of Port Alberni—who passed away only last month—Jack Burke, and Alfred Carmichael, a jolly, lively, retired real estate businessman of Victoria.

The mill died of starvation yet it was located in the midst of plenty. It depended wholly upon rags and ropes for raw materials, not wood. Some of its supplies came from England via the Horn, from San Francisco, Victoria and its naval dockyards, and from every remote village along the Pacific coast. Supplies became scarce—Alfred Carmichael said he "had to make sure his trousers were on securely or they, too, would go into the pot."

Finally, after supplies of old ship sails, overalls, and miladies' fineries dwindled to the point of extinction, the paper mill crew endeavored to make a paper using braken fern. Indians and whites of the Alberni Valley probed every dale and glen plucking ferns. The experiment wasn't too successful, however, for the digesters—small round "pressure cookers"—only partly cooked the fern so that the end product contained slivers of fern, rope, cloth, and other ingredients that the cook—whose name wasn't Mulligan—could find close at hand. At last the predictions of those blessed with hindsight came true. In late 1896 the mill closed.

The idea to build the paper mill originated in St. Andrews Presbyterian Church in Victoria. Reverend McLeod met William Hewartson, a retired papermaker from England, and listened to stories about paper manufacturing. He introduced Hewartson to sharp-witted promoter Herbert Carmichael, cousin of Alfred Carmichael. Herbert became enthused over the idea of building a paper mill and immediately began work on gathering money to build the mill and buy equipment. In short order he raised the necessary funds—$27,500 according to Alfred. (Present-day paper mills cost $30 to $50 millions to build.)

Alfred arrived in Victoria from England in 1890, a boy of 16. A year after arrival he found himself on the paper mill site helping build the mill. Robert Wood, construction contractor for the paper mill's dam, and who later founded the original operations which eventually grew into Alberni Pacific Division of MacMillan & Bloedel, set Alfred to pumping water into a sawmill boiler. Alf pumped steadily for three days. . .the pump lifted only a cupful at each stroke.

By this time George Bird had arrived from Victoria—alone on a chip-sized tug.

The twelve employees earned their pay—about 25 cents an hour for a 10-hour day. Two men looked after the paper machine; three kept the beaters going; one handled the revolving boilers; a fireman kept the pots a-boiling; two Indian girls ran the cutting machine; one man and Mrs. Morrisson looked after the finishing room. Twelfth man was mechanic, millwright, blacksmith.

B. C.'s first paper mill, by sheer good luck and the resourcefulness of its employees and financiers, managed to make several tons of paper products daily. Most of the products were of surprisingly high quality, according to the standards of the day, and included wrapping, building, and blotting papers. Water power to run the "toy" mill came from the dam built a few yards upstream from the sawmill and conducted to the paper mill by a wooden flume. Unfortunately, however, the second-hand and already obsolete machinery that had been bought in England and shipped by vessel was designed to make paper only from cloth—not from wood pulp. Therefore when the supply of rags and rope ran out the mill could not live upon the abundance of cellulose fiber that grew nearby.

With machinery already overdue for scrapping, with inexperience—one foreman of the papermill's sawmill was really a dog-tax collector—and imperfect understanding of conditions and marketing on behalf of the promoters, the reasons for its failure are not hard to understand. Besides, the years 1894 to 1901 were difficult ones in B. C. Population was limited and heavy competition from mills already established on the coast had to be faced. Transportation hazards, high freight charges (yes, then too!) inadequate shipping facilities—all threw their weight on the scales of heavy overhead. Political uncertainty and instability hung over the province. Government succeeded government and the province was in debt; discord rode through the legislative offices.

Jack Mazer, president of Hudson Pulp & Paper Corp., accepts first Annual Award from Nathan Straus III, president of the American-Israel Chamber of Commerce and Industry, Inc. The award was tendered Mr. Mazer in recognition of his efforts in establishing the only paper mill in the Middle East at Hadera, Israel

Under such unfavorable circumstances the paper mill was born. Though the effort was courageous, understandable errors brought its untimely death. But the few surviving old timers who ran the works still smile about their part in operating B. C.'s first paper mill.

Hudson

Jack Mazer, president of Hudson Pulp & Paper Corp., has been awarded the first annual award of the American-Israel Chamber of Commerce and Industry, Inc.

The award to Mr. Mazer was made in recognition of the establishment in Israel, through the efforts of his company and the Abraham Mazer Family Fund, Inc., of the American Israeli Paper Mills Ltd., at Hadera, Israel. This is the only paper mill in the Middle East, representing an investment of four million dollars and having an annual capacity of 14,000 tons.

C.Z.

Crown Zellerbach Corp. plans to construct a new central research laboratory at Camas, Wash. It is expected that the building will be ready for occupancy in April, 1955.

The structure, containing approximately 24,000 sq. ft. of usable floor space, will be three stories high, of steel and concrete construction, and be located immediately west of the development laboratory which was built two years ago to house a complete experimental pulp and paper mill, pilot plants, and development laboratory staffs.

The new laboratory building and facilities will serve all mills, logging divisions, sales divisions, and converting plants of Crown Zellerbach.

The new building will accommodate approximately twice the present operating staff, the administrative staffs, and will provide ample laboratory facilities for all pulp and paper research functions and by-products research. Crown Zellerbach's collection of scientific books and literature, considered to be one of the finest in the pulp and paper industry, will be located in a special library section on the third floor. Another feature will be an auditorium capable of seating 150 people. In addition to conference use by research and development laboratory staff members it will be available to classes of the Crown Zellerbach Paper School.

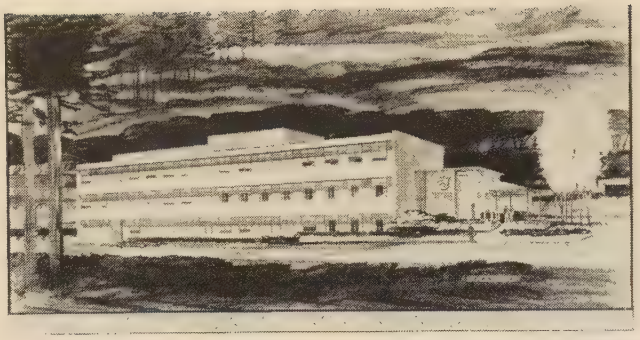
The existing research laboratory, built in 1938, will be turned over to the Camas mill for its use.

Crown Zellerbach Paper School held its 21st annual graduation March 18–19 at Camas, Wash. This unique four-year, college-accredited school headed and conducted by Crown executive, managerial, and supervisory personnel has to date bestowed graduate diplomas on 364 students who completed all four years and 3200 diplomas to those completing the first-year course.

The official program said: "To those who have completed the four year course and to the undergraduates must go the credit for the major part of the success of this adventure in adult industrial education. The interest and enthusiasm of these men and women, and those who during the past 21 years have completed in part or in whole the studies, have made it a worth-while undertaking."

In addition to Camas mill students, the 1953–54 total enrollment of 220 included 92 from the Crown operations in Oregon. Of the latter, 46 were from West Linn, 12 from Portland and North Portland and 33 from St. Helens.

As to the value of the paper school, the organization feels it would be difficult to measure the monetary worth resulting to either the employee or employer. "However," it states, "as to value in promoting a better understanding between departments in the mill and between different mills in the organization, there can be no question. What this means to the human side of this industrial operation should be as evident as the forest of young trees which will some day supply the raw material to provide the wood to make the chips to



Proposed new research laboratory for the Crown Zellerbach Corp.

make the pulp to make the paper, which will provide the job with which we in the organization make our livelihood."

The paper school, headed by regents—Vice-President R. O. Hunt and Resident Managers George H. Gallaway and Malcolm J. Otis—is staffed with administration and faculty personnel from CZ West Linn and Camas plants and offices. The administration staff consists of Dean F. W. Flynn, assistant kraft mill superintendent at Camas; Associate Dean C. A. Enghouse, assistant resident manager at West Linn, and Principal L. F. Maybach, project engineer at Camas.

Crossett

The Crossett companies had their beginning more than 50 years ago a sawmill operators. As a result of a merger which took place last year, The Crossett Co. is now the corporate entity made up of three principal manufacturing divisions: Crossett Lumber Co., Crossett Chemical Co., and Crossett Paper Mills.

Crossett Paper Mills' present kraft pulp and paper plant was built in 1937, and has grown steadily over the years to its present capacity of 450 tons per day.

With Crossett's large land and timber holdings and its extensive forestry program, it was vitally interested in increasing the utilization of the products from its forests, which grow considerable quantities of various species of hardwoods. It was with the use of these hardwoods in mind that the new unit was planned. While the present kraft mill uses only pine, the new mill will use a large percentage of hardwoods which will be pulped by the neutral sulphite semichemical process.

After the Crossett organization had conducted research for a number of years in the utilization of hardwoods in papermaking, J. E. Sirrine Co. of Greenville, S. C., was retained as consultant to assist with the preliminary work of preparing cost estimates, plans, flow sheets, and report prior to final approval by the board of directors to proceed with the project. In July, 1953, this work was approved and Sirrine was commissioned to start actual design without delay.

This new unit is being built completely separate from the present kraft mill but will be operated as an integral part of Crossett Paper Mills, the Paper Division of The Crossett Co. The two mills will be connected by pipelines since the new mill will use a furnish of mixed pine and hardwood pulps in the production of bleached food container board and related products. The initial production will total 150 tons of finished product per day.

Steam from the present power plant will be supplied to the hardwood mill for all uses, and the fire protection system will be interconnected using the existing 100,000-gal. elevated storage tank for both plants.

NSSC black liquor will be returned to the kraft mill and blended with the kraft liquor ahead of the evaporators. There will also be interconnecting lines for hot and cold water from facilities at the kraft mill to the new mill, and waste water from the new unit will be returned to the old mill for use as cooling water for the jet condenser on the evaporators.

Electrical power is to be purchased from Arkansas Power & Light Co., with a tie-in to the power plant at the present kraft mill at 13.8 kv., with primary distribution to unit substations at strategic locations, where it will be stepped down to 440 and 2300 v. for motor application.

The new unit is to be located southwest of the existing mill, and will consist of the following facilities:

1. Woodyard.
2. Chip preparation area.
3. Digester.
4. Refining, washing, and screening.
5. Bleach plant.
6. Stock preparation.
7. Machine room.
8. Finishing and shipping.
9. Chemical area, which will include chemical handling such as unloading, storing, etc.; as well as chlorine dioxide, neutral sulphite liquor, and sodium hypochlorite manufacturing.
10. Water supply and waste disposal.

The woodyard is to include the necessary log conveyors of the chain type to move logs from storage or unloading areas into the 12-ft. diameter by 45-ft. drum type log barker. Sorting of the barked wood is to be provided between the discharge of the drum and the chipper on a multiple strand flat chain conveyor, with a return conveyor to the inlet of the barking drum for rejected wood. Bark will be removed from under the barking drum by a rubber belt conveyor.

One of the present 96-in. chippers at the kraft mill is being replaced; it will be used for the initial production. Chips are to be conveyed by a rubber belt from the chipper to a small surge hopper where they will be fed to the chip screen by a rotary (Star) feeder. This rotary feeder regulating the flow of chips is to be used in order to get the best possible operation from the screen.

Rejects from the screen will be crushed in a hammermill type crusher and returned to the screen by a pneumatic conveying system. Sawdust will also be removed from the woodroom by a similar system.

Accepted chips are to be conveyed by a rubber belt to storage in a structural tile silo. A table type rotary feeder is to be installed to remove the chips from storage, depositing them onto a rubber belt conveying system for transfer to the digester when charging. A very powerful electromagnet is to be provided above the belt conveyor to remove ferrous metals prior to the cooking process.

A continuous weighing device, with integrator, for batch operation is to be used to weigh each charge of chips. The proper electrical controls and interlocks are to be used so that the entire charging operation will be push button controlled from the digester operating floor.

The 3500-cu. ft. stationary digester will be of stainless clad material and of sufficient size to produce the necessary amount of bleached neutral sulphite semichemical. The most suitable types of instruments are to be included for accurate cooking control, remote controlled hydraulically operated blow valve, vertical blow tank with bottom agitator, pumps, etc.

Refining in the primary stage will be accomplished by a large double rotating disk refiner. The refined stock will be pumped directly to the two-stage, valveless type countercurrent washers of all stainless steel construction. The washed stock in turn will be passed through a secondary refiner (an exact duplicate of the primary) before the screening operation, which will consist initially of two rotary screens.

Accepted pulp from the screens will be further cleaned by the use of centrifugal separators for removing dirt specks, sand, or large sheaves. Discharge of this stock from the centrifugal cleaners will go directly to a valveless thickener, with belt conveyor carrying the thickened stock through a heating mixer to a structural tile, high density storage chest of 120 tons capacity. The thickener is to be an exact du-

Bleached board unit proposed by Crossett Paper Mills

ication of the washers, and is to be so arranged as to become third-stage brown stock washer when production demands dditional capacity.

The refiners are to be installed so that either may operate primary or both may be used in parallel, with no secondary fining. This will permit continued production at a reduced te in the event one refiner is out of service.

Kraft pulp, after washing and screening at the present mill, ll be pumped at 3% to a thickener and high density storage nk at the new mill, where it will be bleached intermittently d stored in conjunction with NSSC operation.

The bleach plant is to be of the most modern design, utiliz- g valveless washers, one low density chlorination stage, d three high density stages, for caustic, hypo, and chlorine oxide; and may be operated to produce pulps of low or ry high brightness and high strength on either the hardwood SSC pulp or kraft. High density storage facilities are to provided for three grades of pulps from the bleach plant. ubber belts will be furnished to convey pulps from the washer scharge to storage. Pumps, piping, mechanical equipment, d instruments will be of materials best suited to withstand e corrosive action of the bleaching chemicals.

Stock preparation for this mill will be rather complicated th the use of three separate raw stocks, plus broke, as well facilities for blending, coloring, sizing, etc. The refining to be done in two stages: first, by wide bar type refiners, d second by conventional jordans. Pulp from the high nsity storage towers will be pumped through 6-ton tile ge chests to the refiners; and passed then to either a blend- g tank or three other tile chests for delivery to the machine.

This department will also be equipped with the necessary nsistency regulators, pumps, chests, controls, and equip- nt for continuous preparation of starch and size, as well colors and other furnishes, to provide varying mixtures for er and filler stock for the machine. Piping and controls l be so arranged that either filler or liner stock may be sup- ed to any or all of the vats on the machine.

The 216-in. cylinder machine is to be ultramodern and with e latest innovations incorporated in the designs of the vats, which there will be five initially with space left for three ditional in the future. These vats are arranged for 60-in. meter by 216-in. face molds and will be provided with cial flow chambers to permit operating any cylinder as iflow or counterflow, with or without overflow. The direc- n of the flow into the vat will be accomplished without ernation to the entering or overflow chambers through cial piping arrangements and a four-way valve. Vat es can be adjusted without shutting down the machine.

The flow distributors will consist of stainless steel spreading mbers on each side of and for the full width of the vat. series of valves between the spreading chamber and the rance flow passage to the vat will allow for adjustment as roup or individually.

Each vat will be provided with proportioning devices and angement for deaerating white water by passage through tile collecting boxes at the back of the machine, each of which will connect to a fan pump of 12,000 g.p.m. capacity.

In addition to 24-in. couch rolls for each of the cylinders, the machine will have a 36-in. suction drum press, with two plain primary presses following. There will also be one 34-in. suction primary press and a first plain type main press.

The second press will be of the inverted suction type with the plain roll of hard rubber, and will be followed by six 60-in. paper driers ahead of the heavy duty plain type third press.

After the third press, there will be sixteen 60-in. driers followed by a breaker stack and the third section of sixteen 60-in. driers leading to a size press, which will be followed by eight 60-in. after-driers. All of these driers will be suitable for 75 lb. of steam pressure.

The first section between the presses will have one top return felt drier. The second section will have two Feeney driers and one felt drier on top. The third section will be provided with one top and one Feeney felt drier. The fourth section will have one return felt drier. No felt equipment is provided for bottom driers.

Following the fourth drier section will be two 9-roll calender stacks with 20-in. top rolls, 16-in. intermediate, and 34-in. bottom rolls.

Following the calender stack will be a reel and then a cutter, with the winder placed far enough ahead of the latter to allow for transportation of sheets to the finishing room. An aperture will be left in the floor so that edge trims not put into sheets can be dropped to a special winder in the basement.

For driving the machine a differential drive will be used, with a steam turbine as prime mover and helper motors on the wet end. The turbine will receive steam delivered from the present boiler house at a minimum pressure of 350 p.s.i. so as to allow for pressure drops in the line between it and the generating point, which will be at 400 p.s.i.

Adequate dry and wet broke handling systems will be provided, with white water return to an 8 by 16 vacuum saveall.

Auxiliary equipment for the machine will consist mainly of two vacuum pump units, one for 5600 c.f.m. at 22 in., and another for 6200 c.f.m. at 10 in. There will be two mill compressors and two instrument compressors, continuous oiling system; and the machine room itself will be served by an electrically operated crane, with two 20-ton trolleys.

Equipment is being supplied to finish the ship in either rolls or sheets. Rolls from the machine, after wrapping, will be carried by a power-operated conveyor to a material and service elevator at one end of the building, where they will be taken to the basement for storage or shipment. Sheets will be handled by lift trucks and pallets on the same elevator. There will be a covered shipping platform at basement level for both railroad cars and trucks.

At the north end of the plant will be a chemical preparation area with all equipment necessary for storing, unloading, and making up the neutral sulphite and chlorine dioxide liquors. Chemicals for stock furnish, such as alum, size, starch, titanium, etc., will be unloaded to and prepared in the basement of the stock preparation room. There will be two separate tracks for chlorine cars adjacent to the bleach plant, with provision for vaporizing, as well as continuous preparation of sodium hypochlorite and caustic bleach liquor.

Water will be supplied from nine wells in the adjoining area and pumped to a cold lime softener to be located at the existing kraft mill. The water from the softener is to be stored in a concrete reservoir and pumped to the new mill for use in process. Part of this water will be diverted and pumped through the condenser of a new evaporator unit to be installed at the kraft mill, from which it will be delivered to a warm water storage tank at the new mill, so as to provide hot water after being pumped through a controlled heat exchanger.

Some additions to the present kraft mill will be necessary

in order to furnish the kraft pulp for the new unit. These will consist mainly of a new set of evaporators to take care of the removal of 140,000 lb. of water per hour, two additional 2800 cu. ft. carbon steel digesters, with some changes to the kraft stock chests and to the causticizing plant; as well as the addition of a 12 by 45-drum barker, a new chipper and screen for the present woodroom. The existing kraft mill has already under way the installation of a new bark boiler and the hardwood unit program will involve the further addition of water walls to other of the existing boilers.

Waste from the new mill will be combined with that from the kraft mill before discharge into an impounding basin with an area of 160 acres.

The buildings for the entire mill are to be constructed of structural steel frames and reinforced concrete floors. Roofs are to be of precast concrete slabs with built-up section of roofing paper, asphalt and crushed stone on top. The machine room, finishing and shipping, and bleach plant are to have cork insulated roofs. Walls of all of the buildings are to be a combination of masonry, corrugated asbestos, and corrugated plastic. Foundations will consist of bell bottom piers bored into the soil and concrete filled with reinforcing where required.

Adequate heating and ventilation is being provided for the comfort of the employees and for the protection of equipment.

The construction of the new unit will be undertaken on a firm bid basis from plans and specifications furnished by J. E. Sirrine Co., Greenville, S. C.

The principal vendors of equipment with whom orders have been placed are as shown below.

The Bauer Bros. Co., Springfield, Ohio, refiners, screw feeders, drainer conveyor, and Centri-Cleaners
Beloit Iron Works, Beloit, Wis., high-speed cylinder machine with differential drive
Builders-Providence, Inc., Providence, R. I., weightometer
Carthage Machine Co., Carthage, N. Y., 104-in. chipper
Chicago Bridge & Iron Co., Atlanta, Ga., digesters
Consolidated Western Steel, Houston, Tex., structural steel
Electric Steel Foundry Co., Portland, Ore., digester strainer supports
Fibre Making Processes, Inc., Chicago, Ill., barking drums
Improved Machinery, Inc., Nashua, N. H., blow tank agitator, brown stock washers, bleach plant mechanical equipment, and bleach washers, broke saveall, and poppet valves
E. D. Jones & Sons Co., Pittsfield, Mass., pulp master
Link-Belt Co., Houston, Tex., rotary chip feeder and screw conveyor
Ben J. Malone Co., Memphis, Tenn., ventilation system for pulp mill
Manning, Maxwell & Moore, Inc., Muskegon, Mich., cranes
Mathieson Chemical Corp., Niagara Falls, N. Y., ClO_2 liquor making process
The Orville Simpson Co., Cincinnati, Ohio, chip screen
Paul Valve Corp., New York, N. Y., blow valve
Reliance Electric & Eng. Co., Houston, Tex., motors
The Sandy Hill Iron & Brass Works, Hudson Falls, N. Y., transfer pumps
Shartle Bros. Machine Co., Middletown, Ohio, stock preparation equipment
Chattanooga Boiler & Tank Co., Chattanooga, Tenn., tanks
Swenson Evaporator Co., Harvey, Ill., evaporators
Warren Steam Pump Co., Inc., Warren, Mass., various pumps
The Waterville Iron Works, Waterville, Me., chip crusher
Weaks Supply Co., Monroe, La., belt conveyer material

—by D. G. Moon, J. E. Sirrine Co., Greenville, S. C.

Donnacona

The mills of the Donnacona Paper Co. are located on the relatively small, flat delta formed by the Jacques Cartier River as it joins the St. Lawrence some 28 miles west of Quebec City. The main Montreal-Quebec highway is just to the north of the mill, the Jacques Cartier River runs along its western edge and, in front to the south, is the broad St. Lawrence. A branch of the Canadian National Railways almost bisects the mills, thus they are well provided with highway, rail, and water transport. Completely integrated, the company operates its own woodlands, drives or transports its pulpwood in its own vessels, makes all its own pulp, and even owns a fleet of three motorized canal boats to ship newsprint direct to New York City via Lake Champlain and the Hudson River.

Woodlands Operations

The company's timberlands now comprise some 1721 square miles located in four separate areas. Closest to the mills are the Jacques Cartier limits of 748 square miles, all the wood from which is driven down the river in the spring of each year. The Sault-au-Mouton limits of 112 square miles and the Bersimis limits of 749 square miles are located on the north shore of the St. Lawrence River, east of Quebec City, and the cut wood is transported to the mills by river boat. The fourth area lies on the Gaspé Peninsula and consists of 112 square miles, and this wood will also be brought to the mills in boats. Altogether some 200,000 cords have to be provided each year. Of this about 150,000 are cut on company limits and the balance is purchased.

Cutting operations are so scheduled that the woodlands are on a sustained yield basis. In other words, in each area a little less than the annual growth is cut. Unless some disastrous fire or pestilence occurs, there should be just as much wood available twenty years from now as there is today. In fact, it is quite possible that the yield can be increased through modern methods of woodlands care. To this end, the company has a 45-square mile freehold limit at the southern end of the Laurentide National Park, some 60 miles north of Quebec City, which has been developed by a Tree Farm. By a process of selective cutting and constant growth surveys, ideal methods of cutting, and of fostering new and quicker growth are being worked out. Information gleaned from this experimental plot will gradually be used in the other areas, thus in addition to sustained yield, it will be possible to increase the allowable annual cut.

The logs which are driven down the Jacques Cartier River eventually reach the holding booms immediately above the mill dam. Here, they are taken out of the river on the jack ladder and passed through a drum barker. The logs are conveyed to the mill proper by a water flume, while the bark is used to build up a small island below the dam. As the logs enter the mill, they can be directed either to the woodroom or to the log stacker, where some 50,000 cords are piled for Winter operations.

Pulpwood from the North Shore and Gaspé areas is unloaded from the river boats and piled to the south of the mills. This, too, is a Summer operation, because in Winter, ice floes, and even solid ice, usually closes navigation from November 15 until May 1.

The Pulp Mills

The four digesters in the Sulphite Mill have a yearly capacity of 50,000 tons of unbleached sulphite. In this process, the logs are cut into small chips and then cooked in digesters with a solution of calcium bisulphite under heat and pressure. This breaks the chips down to individual fibers by dissolving the lignin which binds them together. The pulp is washed and screened and is then ready for use. A special process is used to precipitate the lignin from the spent cooking liquor; the lignin is then used as a binder in the Insulating Board Mill.

Groundwood pulp is made by pressing logs against a large grindstone. The abrasive surface of the stone removes successive layers of fibers which are collected as a slurry. These are washed and screened and form the major constituent of newsprint. The 39 grinders in the Groundwood Mill have a yearly capacity of 140,000 tons. All of the groundwood is used in the paper or board mill, but there is a 30,000-ton surplus annually of unbleached sulphite which is sold to other paper manufacturers in Canada or the United States.

The Paper Mill

The three machines in the Paper Mill are parallel to one nother. Numbers one and two are 160 in. wide and number hree is 234 in. or 19½ ft. wide. Prepared fibers are diluted vith 99% water and flow onto a moving wire screen which llows the water to drain through, but traps the fibers on ts surface. From the wire, the web of paper is fed to rolls vhich smooth and press it, and then, on to a series of heated olls, to dry it. At the dry end of the paper machine, it s first wound in huge machine rolls, and then slit and re-vound to desired widths. These narrower rolls are wrapped nd loaded directly to freight cars at the side of the mill, r sent down to the dock area to be loaded into one of the arriers.

The Board Mill

The Board Mill makes two main products, Donnacona In-ulating Board and Donnacona Sheathing Board. The in-ulating board is designed for inside construction and may be f the characteristic buff, rough cast finish, in ½-in. thickness, r one of the many decorative or acoustical types, finished on pecialized machinery. Sheathing board is a water-resistant oard used as the outside sheathing in place of the conven-ional tongue and groove lumber. Both types are made by he same equipment, and both are made from a rather coarse ood pulp to which suitable binders have been added. In he case of sheathing board, a bituminous additive gives it s water and weather-resisting properties.

The prepared pulp is brought to the desired consistency and hen piped to a large tank in which a wire-cloth covered roll evolves. The water drains through the wire mesh depositing thick layer of pulp on the surface. The wet mass is con-inuously stripped off the roll and an ingenious saw cuts the trip into sheets 8 by 13 ft. These travel down a roller onveyor to a large hydraulic press which squeezes out excess ater and delivers the sheets to the tunnel drier. In this, he sheets are carried along slowly, all the while being sub-ected to heated air which absorbs the moisture.

After drying, the sheets descend to the cutting saws which rim them four sides and cut them to the desired dimensions. hey are then wrapped and shipped. Other sheets may be iven a smooth surface, cut into 12-in. squares, beveled, ainted on a spraying machine, and then drilled with nu-nerous holes to form the well-known acoustical tile for noiseless eilings. If thicker sections are required, two or more sheets nay be laminated. A number of different types can be pro-uced on special machinery which sands it to a smooth surface, hapes it into various moldings, and decorates it with cut-n patterns.

MEAD

Mead is a 31-machine mill. Count them all: eleven paper nachines at Chillicothe, one dry pulp machine at Bristol, wo board machines at Lynchburg, and so on. Line them p, and you'll get some idea of our productive capacity. Yes, Mead has 31 of these giant papermakers. A 32nd joins ne ranks this Summer with the start-up of the 216-in.-wide nachine at Rome Kraft Co.

Our baby is 90 in. wide; our largest is number ten at Chilli-othe, with its 218-in.-wide wire. Some (like the combina-ion cylinder-fourdrinier machine at Wheelwright) may nch along at 40 ft. a minute. Macon Kraft's Buccaneer nunders along at 1430 ft. a minute.

It costs more than $2 million to build a paper machine oday though 15 years ago you could have bought the same nachine for about $¾ million.

Our machines can make 5,530,000 lb. of paper and pulp nd paperboard a day. Last year they spun out 294,992 ons of white paper and 339,142 tons of container board.

If you put all our production for the year into a ribbon as wide as this book, it would wrap the center of the earth 572 times, or would reach 30 times to the moon and back.

WEYERHAEUSER

A hydraulically powered log splitter and a 12-ft. floating rip saw, both of which incorporate unique design features, are helping Weyerhaeuser Timber Co.'s Everett lumber division improve whole-log utilization and speed the handling of oversize logs.

Designed and developed by local Weyerhaeuser personnel, the new machines represent a further step in the efficient use of all the forest harvest.

Located at Mill C, the hydraulic log splitter develops 65 tons pressure using water from the hydraulic barker pumps. Operating on a hydraulic ram principle, the splitter forces 8-ft. logs through four knives arranged in a criss-cross or tic-tac-toe pattern. Logs up to 42 in. in diameter are split to a maximum width of 12 in. The split pieces can then be chipped and conveyed to the adjacent Weyerhaeuser pulp mill.

Believed to be the biggest ever built, the new splitter is unique in moving the log rather than the splitting knives. The specially designed knife pattern and the adaptation of water pressure for power are also original design features.

The 12-ft. rip saw is housed in a covered shed mounted on two pontoons which provide a floating platform. Located on the log pond in front of Mill C, the big chain saw rips huge logs down the center, so that they may be conveniently handled by the sawmills. Logs 6 ft. in diameter and larger, too big for the headrig to handle efficiently, are halved and then quartered in a fraction of the time it formerly took to do the job with wedges and sledges.

Logs are floated into position between the two pontoons, locked in place with pins from each side, and ripped down the center by the chain saw which moves the length of the shed on its carriage. The saw, driven by a 30-hp. electric motor, is positioned hydraulically.

Both the hydraulic splitter and the floating rip saw were designed and developed by Weyerhaeuser with Alan Smith, plant superintendent, and Ted Fuller and Howard Hunt, assistant superintendents, playing key roles.

F.P.L.

Comparison tests of 48 wood-preservative chemicals used on more than 7500 wood stakes installed in decay and termite exposure areas are described in a report recently issued by the U. S. Forest Products Laboratory, Madison, Wis.

The report, No. 1761, "Comparison of Wood Preservatives in Stake Tests," is one of a series describing the service life of stakes treated with various preservatives and comparing their durability to that of untreated stakes. The test stakes have been installed at various times since 1938 in Saucier, Miss., Madison, Wis., Bogalusa, La., Jacksonville, Fla., and the Canal Zone, Panama.

Another of the Laboratory's information leaflets on foreign woods has also been issued. This report, No. 1974, describes Obeche, a wood found in most of the countries of West Africa.

Report No. 1665-7, "High-Frequency Dielectric Heating," discusses briefly much of the recent work on the use of dielectric heating to season wood. The report points out the equipment needed and the costs involved, and includes a list of references.

"Board Materials from Wood Waste," Report No. 1666-21, has been revised to include a brief summary of the processes, economics, resin requirements, and equipment needed to manufacture building fiberboards from woods and mill residues.

Reports have been issued from time to time by the Laboratory in cooperation with the Air Force-Navy-Civil Subcommittee on Aircraft Design Criteria. Report No. 1823-A, "Supplement to Fatigue Tests of Glass-Fabric-Base Lami-

nates Subjected to Axial Loading," is the most recent of this series to be issued. The report correlates fatigue data on glass-fabric laminates with stress-rupture data on the same material.

Other publications recently issued by the Laboratory include: "List of Publications on Chemistry of Wood and Derived Products," No. R238; "List of Publications Relating to Fungus Defects in Forest Products and to Decay in Trees," No. 508; "Partial List of Reference Works on Pulp and Paper," No. 564; and "List of Publications on Box and Crate Construction and Packaging Data," No. R791.

These reports may be obtained free of charge as long as the supply lasts by writing the Director, U. S. Forest Products Laboratory, Madison 5, Wis.

NEPCO

Joint planning and study by research and manufacturing departments of Nekoosa-Edwards Paper Co. have led to a plan for a very substantial reduction of pulping waste with resultant improvement in river conditions.

The plan, latest development in NEPCO's continuing conservation and area improvement efforts, has been officially approved by the state committee on water pollution. It calls for a reduction of sulphite pulp production over a period of years of up to about 60%, thus eliminating a corresponding amount of waste liquor. An extensive series of ponds, already in service, will be used to absorb the remaining waste. In percolating through the soil, harmful materials are removed from the liquor.

To replace the decrease in sulphite pulp production, additional kraft pulping facilities and a new recovery furnace will be constructed at Nekoosa, beginning late in 1954. It is planned to have the over-all project in operation by early 1958.

The company has earmarked $\$1^1/_2$ million for this new construction as the first step in the plan.

A newcomer to the engineering department of Nekoosa-Edwards Paper Co., Port Edwards, Wis., is Robert E. Simkins, formerly of Seattle, Wash.

Olin

A single black powder company founded in 1892 in East Alton, Ill., was the seed from which Olin Industries, Inc., has grown. Olin is now one of the nation's more diversified industrial enterprises with 18 plants in 14 states manufacturing an ever-widening range of products in eight different fields based essentially on metals and chemicals.

As a "growth" company, Olin has been following for many years a well-defined program of diversification, largely into related fields.

Olin has grown upon a sound foundation of experience in its own right and the acquisition of successful and profitable companies.

From its small beginnings 62 years ago, the company now has about 19,000 employees in its own plants. It also operates three government-owned facilities employing approximately 11,000 persons for the production of ammunition and explosives in support of the national defense program.

The company is presently composed of nine operating divisions: Arms and Ammunition, Paper, Electrical, Explosives Forest Products, Metals, Film and Ramset (manufacturers of powder-actuated tools and fasteners) and the International Division.

The original Olin company was founded by F. W. Olin, who died in 1951 at the age of 91. Today the enterprise is headed by his two sons, John M. Olin, president, and Spencer T. Olin, first vice-president.

The first Olin enterprise, which manufactured black powder, expanded and now known as the Explosives Division, manufactures industrial explosives, high explosives, Olin Ball Powder, blasting caps and supplies, railroad fuses and torpedoes.

With the elder Olin's invention of an automatic shot shell loading machine as an outlet for black powder, Western Cartridge Co. was formed and ultimately became one of the country's leading producers of sporting ammunition.

One of Olin's early expansions was its construction of a brass mill at East Alton in 1916 to provide its own source of cartridge metal needed to fill military contracts during World War I.

At the end of the first war, having a brass capacity far in excess of its peacetime needs for sporting ammunition, the company entered the commercial brass business. Today with its brass mills at East Alton, Ill., and New Haven, Conn., the company produces nonferrous alloys in coils, strips and sheets, as well as thousands of different fabricated parts for customers throughout the country.

In 1931, in the depths of the depression, the company purchased the Winchester Repeating Arms Co. of New Haven, Conn. It thus added sporting firearms, dry cell batteries, and roller skates to its line of products. In 1952 it opened a second dry cell battery plant at Covington, Tenn.

Olin doubled its brass mill capacity to handle government small arms ammunition contracts for World War II and in its own and government-owned plants produced more than 15 billion rounds, 100 million lb. of aluminum and more than $1^1/_2$ billion lb. of cartridge metal, among many other military items.

During the present defense program, through subsidiaries, Olin is operating the Badger Ordnance Works at Baraboo, Wis., and Wabash River Ordnance Works, Newport, Ind., and is operating the St. Louis Ordnance Plant, which during World War II produced more small arms ammunition than all plants in World War I combined. The corporation is making many other defense contributions in its own plants.

The name Olin Industries, Inc., came into being in 1944 when various Olin-owned enterprises were merged into Western Cartridge Co. which then changed its name to Olin Industries, Inc.

With its more than 50 years of experience in the manufacture of cellulose-base products, the company next entered the cellophane and fine paper industries. In 1949 Olin acquired the Ecusta Paper Corp. at Pisgah Forest, N. C., world famous manufacturer of cigarette paper and other fine papers. The company built its first cellophane plant in the same site and production began in 1951.

Once in the transparent packaging materials field, the addition of polyethylene through the acquisition of the Harwid Co. of Cambridge, Mass., was the next step.

Olin next acquired Frost Lumber Industries, Inc., of Shreveport, La., with 450,000 acres of timberland in Arkansas, Louisiana, and Texas. This has since become the Forest Products Division, producer of southern pine and hardwood lumber, posts, piling, poles, hardwood flooring, and summer furniture.

With the acquisition of Ramset Fasteners, Inc., of Cleveland, Ohio, in May, 1952, Olin entered the growing field of powder-actuated industrial fastening tools and fasteners used in the construction and maintenance fields and many others. Ramset tools use a special type of smokeless powder cartridge as their source of power to drive steel fasteners of many types into steel and concrete.

To complement its well-established position as a producer of explosives for the coal-mining industry, Olin purchased an interest in the Armstrong Coalbreak Co. of Benton Harbor, Mich. This company holds basic patents and sells and services equipment used in the new and rapidly growing technique of mining coal by compressed air.

The formation of the Matholin Corp. to manufacture, sell, and conduct research on hydrazine, one of the most promising of the new commercial chemicals, was announced jointly in

uly, 1953, by John M. Olin, president of Olin Industries, and homas S. Nichols, president of the Mathieson Chemical orp.

Hydrazine, as an important national defense chemical, is xpected to become one of the basic chemicals of the future, ith constantly growing applications in many fields of in-ustrial chemistry. Until recently it has been a laboratory uriosity but some 2000 derivatives have now been reported. he material, or its derivatives, are being used in medicinal, gricultural, plastic, and many other products.

The new company, owned equally by Olin and Mathieson, ill acquire the first commercial-scale hydrazine plant re-ently completed by Mathieson at Lake Charles, La.

Research which always has been dominant as a factor in he company's growth, received a major impetus in 1952 ith the establishment of the Olin General Research Organi-ation. Over 700 scientists, technicians, and others are em-loyed in Olin laboratories.

Olin's steady growth has brought with it a reorganization, oordination, and added depth to its management which, ith resulting efficiency, have produced the highest peace-ime sales in its 62 years.

nion Bag

A" Program

The "A" Program for the Savannah Mill of Union Bag & aper Corp. was undertaken to increase the nominal daily roduction from 1340 to 1760 tons per day of finished prod-ct. Three hundred tons per day of the finished product ere to come from a neutral sulphite semichemical process sing hardwoods and the remaining 1460 tons to be of kraft aper and board production.

Certain facilities under the "A" Program were designed to rovide for additional expansion beyond the 1760 to 1985

Woodyard control tower and section of rotary table. Wood from five-strand chain conveyor is delivered to otary table where a remotely controlled hydraulic plow istributes logs into any one of three conveyors. By djustment of the plow setting, all three conveyors can be fed at once if desired

One of two gantry cranes in Union Bag & Paper Corp.'s woodyard which unloads pulpwood from flat cars directly into flume. Unloading rate is approximately 4 to 5 min. per car

tons per day nominal production. A brief description of the main facilities and equipment furnished each department follows.

Woodyard

Reference is made to a description of the pulpwood flume system as presented to the Eighth TAPPI Engineering Conference.

Kraft Mill

Pulp Mill Office and Locker Room. A new pulp mill office and locker room was required since the semichemical pulp washing plant would be located in the area of the existing office. A building of modern design for the pulp mill superintendent and foremen was incorporated with a locker room for 300 colored and 300 white employees in separate accommodations.

Recovery Unit. A new black liquor recovery unit was furnished by Combustion Engineering, Inc. rated at 350 tons per day of pulp. This is a spray type unit designed for 475 p.s.i.g. 750°F. with 36,642 sq. ft. of total heating surface. Capacity of dry solids per 24 hours in 1,050,000 lb. with steam capacity of 168,500 lb. per hour on the designed black liquor burning rate. Maximum steam generation on oil firing is 200,000 lb. per hour.

Incorporated in the design of this unit was the first installation of a water-cooled furnace bottom in which the boiler tubes, with fins welded on the sides and plastic chrome poured over the tubes form the bottom of the furnace. The smelt creates a level pool 6 in. deep over the entire bottom discharging through the smelt spout at this fixed depth.

Two Cascade evaporators of two wheels each are located parallel to each other at the rear of the unit. Gases pass through the Cascade evaporators to a Cottrell precipitator for the chemical recovery.

The Cottrell precipitator installed with the recovery unit is a Research Corp. unit designed for 90% removal on 160,000

Truck load of wood is being dumped into flume at Savannah plant of Union Bag & Paper Corp. Trucks back into hydraulic lift platform hinged at the flume end and the truck is inclined until the pulpwood starts to roll off into the flume. Only a matter of a couple of minutes is required to lift and dump a truckload of wood

cu. ft. of gas per minute with temperatures ranging from 275 to 300 °F. Construction is of typical precipitator design with 8 in. thick reinforced tile shell and concrete roof insulated with 2 in. of Perlite. In place of the normal reclaiming dust conveyer system the precipitator was equipped with a wet bottom in which a black liquor level is maintained. Two vertical agitators in the precipitator wet bottom provide means of keeping the dust in solution. The dust absorbed in the black liquor is pumped up to the Cascade evaporators.

Evaporator. Additional black liquor evaporator capacity was essential for the expansion program. The only location available for the installation of additional evaporators was in the area taken up by black liquor storage and soap removal tanks. The relocation of these items represented a costly and time-consuming operation. A septuple effect unit was purchased from the Goslin-Birmingham Manufacturing Co. The design rating is to evaporate 370,000 lb. of water per hour from a feed quantity of 506,000 lb. per hour of liquor at 14.35% total solids and 190 °F., with a discharge of 136,000 lb. per hour at 53% total solids. Steam required is approximately 66,400 lb. per hour at 40 p.s.i.g. for maximum requirements. The barometric condenser is designed to condense vapors from the seventh effect using approximately 5640 g.p.m. at 95 °F. river water. The general arrangement for the septuple unit is for divided liquor feed to the sixth and seventh effects pumping from these to the remaining effects. Heating elements of the first and second effects contain type 304 stainless steel tubes. The balance of the effects contain welded steel tubes. Warner separators are used in all effects.

Digesters. Six kraft digesters 10 ft. 3 in. in diameter by 41 ft. 11 in. over-all length were added to the kraft mill. With the additional digesters the existing chip conveyer system from the woodyard would not have sufficient capacity. It was also desired that the digesters for both the kraft pulp operators and the semichemical could be charged from the new woodroom. In order to accomplish this, two shuttle conveyers were installed above the existing digesters and the new ones. Detailed scheduling of the work was essential in order to remove the existing tripper conveyer and install shuttle conveyers during short shutdown periods. The final arrangement provides that 35 digesters can be charged from either woodroom if desired.

Recausticizing Plant. Essential additions to the caustic plant were a new white liquor clarifier and a lime mud washer. Both of these units were purchased from the Dorr Co. The white liquor clarifier is a 40-ft. diameter by 24-ft. deep type A3TB tray thickener. The mud washer is a 40-ft. diameter by 24-ft. deep type A3TB tray thickener for single-stage operation. The mud washer installation is arranged for either a primary stage on the existing mud washer with secondary stage on the new unit or as single-stage operation on all units.

Semichemical Mill

The semichemical pulp mill was designed for the purpose of cooking hardwood under the neutral sulphite process for a nominal production of 265 tons per day. Equipment arrangement and capacity are laid out so that expansion of the semichemical pulp mill to 400 tons per day can be achieved with minimum alterations. For the original installation those items of equipment essential to kraft pulp production were incorporated in the semichemical design with the result that either kraft or semichemical pulp can be produced.

The digesters are similar in design to those used on kraft except that the top of the unit is in the general shape of a sulphite digester to provide for installation of a carbon brick lining. The carbon brick are 9 by 9 by $2^1/_2$ in. curved to fit the radius of the digester shell. The brick are laid in a joint material composed of graded digester quartz and portland cement. In back of the carbon brick is a layer of grout $1^1/_2$ in. thick. The semichemical units have been equipped with digester circulating system. The circulation pipe lines have been arranged for the future possible installation of a heat exchanger for indirect cooking. The digester blow valves are operated from the cook floor through a hydraulic remote control system.

The six digesters blow to a common 24-ft. diameter blow tank. Stock is pumped from the blow tank through a header serving five dewatering screens. Pump capacity is 25% over the maximum usage contemplated, thus furnishing a continuous return of pulp to the blow tank. While the blow tank is equipped with a conventional type agitator, the recirculating stock is used to assist in keeping the chips in suspension as well as alleviating stock line plugging.

Stock going over the dewatering screen has the free liquor removed with the high consistency stock discharging over the end of the screen. Black liquor is then added back into the chutes ahead of the Sprout-Waldron refiners at a manually controlled rate. Vapors released as stock and liquor come in contact with air at room temperature are removed through a stainless steel duct ventilating system.

Primary refined stock discharges from the Sprout-Waldron refiners into a small stock tank, and is then pumped up to

One section of settling basin equipment in flume system in woodyard of Savannah plant of Union Bag & Paper Corp. This equipment removes grit composed of small stones, loose sand, and sand impregnated bark from flume. Grit is discharged from each chamber onto a chain conveyor which dumps load into a load-lugger bucket. Average collection is approximately 4 cu. yd. per hr.

wo lines of Swenson-Nyman 9-ft. diameter by 16-ft. face ashers. Washers are of conventional design but have been rnished with stainless steel drainage tubes. Also, the drain-ge deck consists of stainless steel corrugated plates supported n the drainage channels. In place of the usual sleeve-type runnion bearings, the drums are designed with antifriction earings. Washer hoods are designed with transite supported nside of steel structure with all joints sealed to prevent vapors oming in contact with the steel. Uptake ducts are of stain-ess steel.

Stock from the washers discharges into a tank and is then umped up to the washer floor elevation for secondary refin-ng on additional Sprout-Waldron units. The washed re-ned stock is then pumped over to the screen room deckers.

Instrumentation in the wash plant is in keeping with the odern trend of providing the operators with as much auto-atic control as can economically be justified. Level re-orders on liquor, stock and blow tanks, washer shower flow ndicators, steam and water flowmeter, and blow tank con-tancy controller are the same as in general use. In addition, he vat level recorder on the first drum of each line is tied in ith a Venturi type flowmeter on the individual stock lines eeding the two lines of washers. Stock flow is controlled om the main panel board through a diaphragm operated tock valve ahead of the meter. Dilution liquor to the vat s controlled through a ratio controller actuated by stock owmeter. The main panel board has a diagrammatic lay-ut of the entire wash plant equipment. Each motor is in-icated by a light connected to a signal horn. Whenever otor failure is experienced a horn signal is sounded and op-rators can tell by a glance at the diagram which motor is ausing the difficulty.

In preparation of neutral sulphite cooking liquor a sulphur urning plant is essential. Sulphur is received at the plant n bulk, melted and stored as liquid in one of two insulated nks. Each tank has a capacity of 450 tons. Sulphur is urned in a rotary sulphur burner. Gas is discharged from ne burner into primary and secondary combustion chambers. as then passes through a cooling tower into a chrome nickel eel perforated plate type sodium sulphite absorption tower. iquor from the absorption tower is pumped to a buffering nk where filtered soda ash is added at a controlled rate. rom the buffering tank the finished liquor is pumped to a orage tank alongside the semichemical digester house. his storage tank is 40 ft. in diameter by 26 ft. high with an pproximate storage capacity of 235,000 gal.

Soda ash is received in hopper bottom cars discharging into screw conveyer system which transports the ash to a slurry preparation pit. Under this system soda ash can be unloaded on an average of a 45-ton car in an hour to an hour and fifteen minutes. High-pressure sprays sluice the soda ash into a small pit on the suction side of a 100-g.p.m. pump. This pump discharges into a 62-ft. diameter by 40-ft. high soda ash slurry storage tank with a capacity of 904,000 gal. As additional soda ash is received, solution from the tank is used in the spray system thus gradually building up the amount of soda ash in solution. Actual storage capacity is calculated to be approximately 2900 tons when the soda ash is in a maximum slurry form. For process use a clear solution is withdrawn from the top of the tank, the rate being controlled through a ratio controller. Soda ash is passed through filters and then stored in a tank and used for buffering and in the absorption tower as required. A green liquor storage tank has also been installed. Green liquor is pumped from the caustic plant as available and stored for use as buffering n place of the soda ash.

Crane with grab hook shown unloading pulpwood from cars into flume at Union Bag & Paper Corp.

hip storage silos which are essential part of the plant's ew woodyard set-up. The two units are 40 ft. in diam-ter and have 60,000 cu. ft. capacity, each. One is used for hardwood and one for pine

Paper Mill and Stock Preparation

Stock preparation equipment for the new no. 6 paper machine was installed in a building added to the existing stock preparation room. Stock is pumped from the kraft wash plant up to the knotter headbox discharging to four IMPCO rotary knotters. Accepted stock from the knotters discharges to three Cowan screens. Screen tailings are collected in a tank and then pumped back to the knotter elevation through a rejects knotter for reclamation of fiber. The screened stock discharges to two IMPCO vacuum deckers 8 ft. diameter by 16-ft. face. Located next to the deckers is an 8 by 16-ft. IMPCO saveall for reclamation of fibers from the paper machine.

Deckered stock is pumped from the decker chest through a consistency regulator to the machine chest then to eleven Sutherland 48-in. refiners. Refined stock is pumped through a regulating box, thence through a stock regulating valve feeding into the suction of the mix pump from the wire pit. The mix pump discharges to a deculator assembly with a 6 ft. diameter by 30-ft. long receiver. Deculator capacity is rated at 25,000 g.p.m. Deculated stock is then pumped by a 36 by 30-in. fan pump up to a pressure type headbox. This unit was furnished by the Valley Iron Works Co. The headbox has all interior surfaces of the inlet lined with 16 gage stainless steel, exterior parts of steel being fully Lithcoted.

The paper machine is a Pusey & Jones Corp. 234-in. fourdrinier kraft paper machine designed for a speed of 2000 f.p.m. The fourdrinier is designed for a 120-ft. long wire with 26-in. diameter breast roll 238-in. face, a 44-in. diameter suction couch roll, a 30-in. diameter lump breaker roll at the couch, and a total of ten section boxes. The fourdrinier is typical Pusey & Jones rapid-drape wire handling design for installing the wire from the tending aisle without removing the fourdrinier proper. Exposed structural surfaces have a protective covering of stainless steel.

The press part is a Pusey & Jones simplex arrangement with overhead frames comprising two main press rolls. The upper roll is 36 in. diameter, neoprene covered, 238-in. face. The lower roll is 38-in. diameter suction type cast bronze shell with 236-in. drilled face. Pneumatic air loading system is used to properly distribute the desired weight on the bottom roll. A complete Mason-Neilan system with control valves and gages are mounted in a console type cabinet on the tending side. Press felts pass in a forward direction through the respective presses. Sixteen felt rolls are furnished, with one roll on each felt full wormed on the face with hard rubber to act as felt spreader. A Vickery conditioner fitted with three Jordan type suction shoes is furnished for each press felt.

The drier part is arranged in four sections with one upper and one lower felt on each section, a marking press between the second and third section, and a size press between the third and fourth sections. The four sections have a total of 71 main paper driers, 60-in. in diameter, 16 felt driers, 48-in. in diameter, and one 42-in. diameter receiving drier. Each drier has been dynamically balanced at surface speeds up to 2000 f.p.m. The drier journals run in extra heavy-duty roller bearings enclosed in housings with seals against entrance of dust and oil leakage. Each bearing housing is fitted for connection to a Bowser oil circulating system. All drier gears and idler pinions on the driving train are enclosed in cast iron oil-tight casings, integral with the drier frames, and arranged for lubrication from the Bowser circulating system. The Bowser oiling system is the latest design equipped with a combination receiving tank, filter unit, and clean oil storage tank. Two sets of duplex motor-driven oil pump units complete with automatic controls are included.

Sheahan rope feed paper carriers for threading the sheet through the drier part, Nash automatic felt guides, automatic felt tightener, paper spring rolls at the end of the 3 and 4 drier sections, access platforms and an open grill iron footboard extending the length of the driers are parts of the machine.

The calender stack comprises 8 rolls. All rolls are 228-in. face of chilled iron. Latest type pneumatic system is provided for applying pressure in loading the rolls.

The reel is a Pope type uniform speed reel of special design. The main drive drum is 42 in. in diameter, 228-in. face. The maximum diameter roll of paper which can be reeled is 96-in.

The slitter and winder, complete with unwinding stands, is a two-drum uniform winder suitable for handling rolls up to 60 in. in diameter, 220 in. trimmed width. The winder drums, rider roll, and slitters are balanced for speeds up to 6000 f.p.m. The winder is equipped with the latest design ejecting and unloading device for handling the paper rolls from the winder to the floor.

The air ventilation system was furnished by the Jamar Olmen Co. The paper machine hood and exhaust system have a total exhaust capacity of 550,000 c.f.m. which provides a building air balance of at least 70% of the total air exhausted through the hood. The air ventilation supply systems have a capacity of 429,000 c.f.m. for an air balance of 78% supply of exhaust capacity. The electrical center for paper machine controls and motor generator sets has a separate air supply system rated at 74,000 c.f.m. In addition, the cooling air system for the motors on the paper machine drive has an individual ventilation supply rated at 25,00 c.f.m. at 3 in. static pressure. The winder drive motors and braking generators also have a separate air cooling supply system. Each of the three latter systems has individual automatic oil filtered air intakes.

Management Group of Union Bag & Paper Corp.; Standing, left to right: J. R. Lientz, Manager, Pulp and Paper Division; F. W. Kelley, Manager, Industrial Relations Division; R. T. Inman, Chief Engineer; J. J. Armstrong, Manager, Woodlands Division; A. L. Sopp, Assistant Comptroller; M. R. Hamarat, Manager, Box Division. Seated, left to right: Kirk Sutlive, Public Relations Manager; V. E. (Tex) Kelly, Manager, Bag Division; T. T. Dunn, Vice President and Resident Manager; M. C. Guyot, Superintendent, Planning and Scheduling; and M. L. Taylor, Manager, Technical Division

The paper machine is equipped with a General Electric multiple generator electronic amplidyne controlled sectional paper machine drive for machine speed of 350 to 2000 f.p.m. Drive motors are rated at 550 v. Motor sizes involved are 700 hp. for the couch, 200 hp. each on the press and drier sections, and 400 hp. on the calendar stack. The first and second main motor-generator sets have a 1000-hp. 1200 r.p.m. a.c. motor. No. 3 motor-generator set is rated at 900 hp. at 900 r.p.m. The electronic control provides the means of regulating the speed for the various sections of the machine.

The winder is equipped with a 6000 f.p.m. regenerative braking winder drive. The main d.c. panel provides amplidyne control for acceleration and deceleration as well as braking generator current control. The operator's panel is located adjacent to the winder and includes a master combination switch and rheostat for starting, stopping, and speed control.

Power supply is 13,800 v. from the turbine room to a.c. transformers located on the ground floor of the electric control center. Motors are 2300 and 440 v.

Additional shipping facilities were provided by a 280-ft. long extension of the shipping platforms paralleling two railroad tracks. In additional, a new paper mill office and locker room for 200 men was incorporated in the design of the roll handling and shipping building extensions.

At completion of the construction work, roads and storage areas were either finished with concrete paving or a hot mix asphalt to provide easy access to all departments.

du Pont

William H. Dietz, a du Pont specialist in use of pigments by the paper and paint industry, has been assigned to the Cleveland Sales District of the company's pigments department.

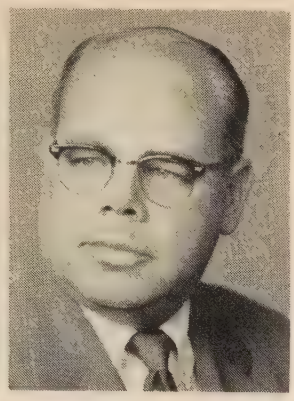
du Pont's Grasselli Chemicals Dept. has published a leaflet (May, 1954, "Chemical Briefs") giving information on quilon for use in improving water repellency, release characteristics, and sizing of papers.

Ebasco Services

Ebasco Services, Inc., New York, N. Y., has opened a new office in Dallas, Tex. W. A. Buchanan has been appointed manager of the new office.

E. D. Jones

W. J. "Pat" Yunker has joined E. D. Jones & Sons Co., Pittsfield, Mass., as its southern representative.



W. J. Yunker, E. D. Jones & Sons Co.

G.E.

The General Electric Co., Schenectady, N. Y., is building a new apparatus service shop at Indianapolis, Ind. This will be the thirty-sixth in the company's chain of service shops.

G.E. awarded a total of $685,842 to its employees during 1953 for 29,939 useful suggestions adopted under the company's suggestion award program.

G.E. has issued a bulletin (G.E.C.-1123) describing a new processed timer designated type TSA-18.

G.E. has issued a new bulletin (GEA-6127), describing a complete line of packaged speed variator drives from 1 to 200 hp.

Stein, Hall

The following are appointments of the Stein, Hall & Co., Inc., 285 Madison Ave., New York, N. Y.: S. Crawford Bonow, manager of the Manufacturing Div., Paul Kaplan, manager of the Technical Div., and Albert R. Robbins, manager of the New York Laboratories.

Graver

The Graver Water Conditioning Co. has published a bulletin (WC-111) containing a comprehensive treatment of the subject of water demineralization.

A leaflet by V. J. Calise, director of Research and Development of the Graver Co., gives a method for quickly calculating the B.t.u. savings from continuous blowout heat recovery.

Langston

The Samuel M. Langston Co., Camden, N. J., has completed a series of moves designed to increase its productive capacity 45% by the end of 1954. Langston has subcontracted the manufacture of its shaftless mill rolls stands to the Fayscott Co., Dexter, Me.

Link-Belt

The Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., has appointed Donald L. Shirley as district sales manager for the Seattle, Wash., area.

Stebbins

The following equipment is being installed by the Stebbins Engineering & Mfg. Co., Watertown, N. Y., in new mills in the south.

Buckeye Cellulose Corp., Foley, Fla.:

- Bleach plant
  - SO_2 tower lining
  - 2 chlorination tower linings
  - 3 hypo tower linings
  - 3 caustic tower linings
  - 10 Semtile seal towers
  - 8 washer vats
- Machine room
  - 2 Semtile white water chests
  - 2 Semtile decker vats
  - Machine chest
  - Broke chest
  - Jordan chest
  - Wash pit and couch pit lining
- Chip silos
  - 2 Semtile chip silos
- Pulp mill
  - 2 brown stock storage chests
  - 2 bleach stock storage chests

Bowaters Southern Paper Corp., Calhoun, Tenn.:

- Washer and screen room
  - Screened brown stock chest
  - White water chest
  - Washed stock surge chest
  - Primary and secondary reject chests
  - Accepted stock chest
  - 2 IMPCO saveall vats
  - Filtrate discharge trough
  - Pulp drier headbox
- Bleach plant
  - 3 washer vats
  - Chlorination tower lining
  - Hypo tower lining
  - Foam tower
  - Seal box for foam tower
  - L.D. bleached stock storage tower
  - Chlor, and caustic washer seal box
  - Hypo washer seal box
  - Stock metering box
- Grinder room
  - Grinder flume linings
  - Gowan screen stock flumes
- Stock preparation room
  - 2 groundwood decker stock chests
  - Clear and cloudy white water chests
  - Screened groundwood chest
  - Coarse screen reject and accepted chests
  - Tailings blending chest
  - Primary refiner rejects chest
  - 2 kraft chests
  - 2 broke chests
  - 2 machine stock chests
  - 2 saveall white water chests
  - 2 saveall feed mix chests
- Machine room
  - 2 machine wire and couch pits
  - 2 machine couch pits
  - 2 machine tray collectors
  - 2 flat box seal boxes
  - 2 dry broke disintegrators
  - 2 sc. stock troughs and pits
  - 2 white water saveall pits
  - Dry pulp disintegrator
  - Wet broke repulper pit
  - White water chest in pulp drier room
  - 2 wet broke chests
  - 2 white water surge chests
  - Pulp drier machine chest
- Chip silos
  - 3 chip silos
- Bleach liquor making plant
  - 3 bleach liquor storage tanks
  - Bleach mixing tank
  - Bleach clarifier tank
  - 2 wash tanks

Rayonier, Inc., Jesup, Ga.:

- Chip silos
  - 6 Semtile chip silos
- Bleach plant
  - Saran chlorinator lining
  - Semtile seal boxes
  - 2 chlorine dioxide bleach towers
  - 2 hypo tower linings
  - 7 Semtile washer vats
  - Semtile hypochlorite bleach liquor tank
- Pulp mill
  - Semtile white water tank
  - Side hill screen boxes
  - Wire pit, couch pit, and white water pit
  - Semtile high density storage tanks
  - 2 Semtile blending tanks
  - Side hill screen chest
  - Vibrotor chest linings

ARABOL

Henry E. Weingartener has been elected executive vice-president of the Arabol Manufacturing Co.

B & W

Henry W. Doctor has been appointed district sales manager for the Tubular Products Div., of the Babcock & Wilcox Co., 161 E. 42nd St., New York, N. Y.

WITCO

The Witco Chemical Co., 260 Madison Ave., New York, N. Y., has opened a new sales office at 1447 Peachtree St., Atlanta, Ga., under the supervision of Clement Damen.

Witco has opened a new factory and laboratory at Droitwich, Worcestershire, England, for the production of latex base paints. Ultimately the new plant will produce the same chemicals as now manufactured in the United States by Witco for the rubber, paint, printing ink, plastics, paper, and grease industries.

FOXBORO

W. W. Frymoyer has been elected vice-president of the Foxboro Co., Foxboro, Mass.

Ross

Charles R. Herter has joined the J. O. Ross Engineering Corp. as a sales engineer in its Detroit office.

CARPENTER

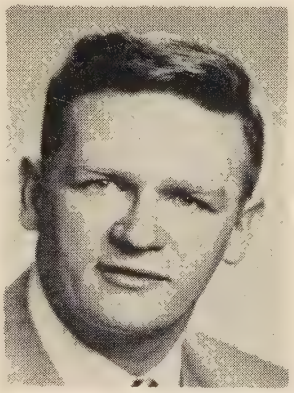
Selden E. Doughty has been appointed production manager of the Carpenter Steel Co., Alloy Tube Div., in Union, N. J.

DE LAVAL

The De Laval Steam Turbine Co., Trenton 2, N. J., has issued a bulletin (1001 B) giving design features and specification data on the De Laval Type GS Pump.

H. G. Bauer has been appointed vice-president and general sales manager of De Laval.

H. G. Bauer, De Laval Steam Turbine Co.



J. L. Hagen, The Louis Allis Co.

LOUIS ALLIS

The Louis Allis Co., Milwaukee, Wis., has opened a new district office at 1713 S. Oneida St., Appleton, Wis., under the direction of John L. Hagen.

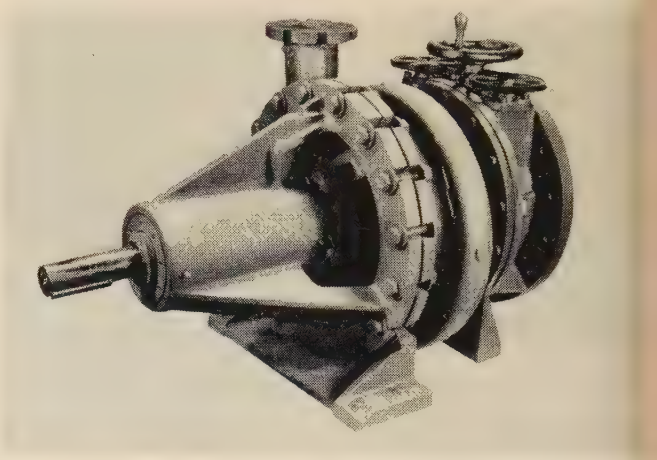
MALLINCKRODT

The Mallinckrodt Chemical Works of St. Louis, Mo., has issued a new photo bulletin giving detailed information on photographic negative reduction.

E. Richard (Dick) Kuehne has been appointed Chicago District Sales Manager for Mallinckrodt Chemical Works, St. Louis, Mo.

A-C

The Allis-Chalmers Manufacturing Co., Milwaukee 1, Wis., has authorized an increase in the number of shares of preferred stock of $100 per value from 259,481 to 618,854.



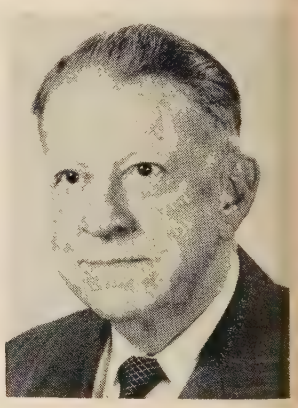
The new Allis-Chalmers variable capacity-variable head pump

A-C is producing a new variable capacity-variable head pump, designated type ACAP, for use in handling any consistency from water up to 5% paper pulp.

C.E.

Arthur T. Hunter and Fred O. Pahmeyer have been elected vice-presidents of Combustion Engineering, Inc., 200 Madison Ave., New York 16, N. Y.

A. T. Hunter, Combustion Engineering, Inc.



F. O. Pahmeyer, Combustion Engineering, Inc.

FULLER

Leonard R. Constantine has been appointed plant manager of the Catasaqua, Pa., plant of the Fuller Co.

GENERAL MILLS

The Spring, 1954, issue of "Progress Through Research," published by General Mills, Inc., Research Laboratories, 2010 E. Hennepin Ave., Minneapolis, Minn., features an article on printed circuits and how they are helping electronic engineers to produce equipment that "takes up no space, weighs nothing, and does everything."

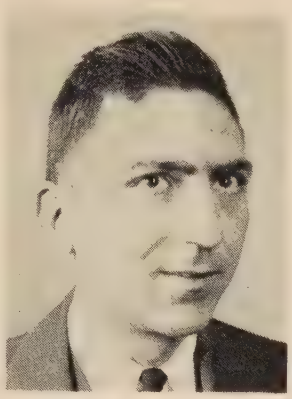
I-R

The Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y., has published a reprint of an article describing how a large tire manufacturing firm installed an 1140-ton steam jet water vapor refrigeration unit.

'. AND J.

H. B. "Whitey" Wilson, Southern District sales engineer or Pusey & Jones Co., has moved his residence to 125 E. 5th St., Savannah, Ga.

H. B. Wilson, Pusey & Jones Corp.



Jack Moss, Pusey & Jones Corp.

Jack Moss, Midwest sales engineer for P. & J., has moved his residence to 409 Monroe St., Kalamazoo, Mich.

HUBER

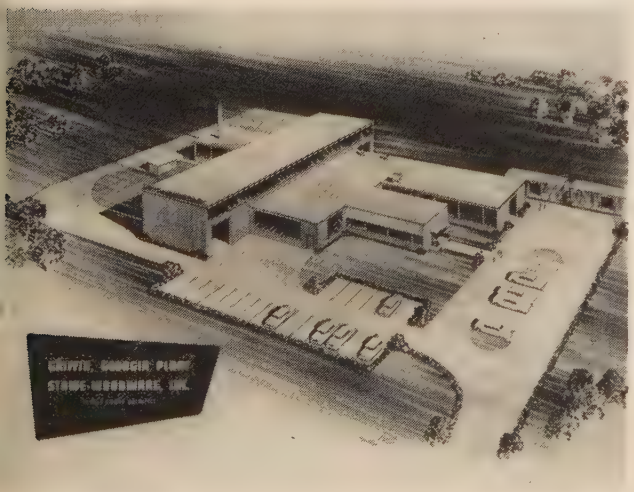
The Spring, 1954, issue of *Huber News* carries a feature article on wallpaper, its history and manufacture. *Huber News* is a publication of the J. M. Huber Corp., 100 Park Ave., New York 17, N. Y.

J-M

Johns-Manville Corp. has begun building a new plant at Lompoc, Calif., for the manufacture of synthetic silicates from diatomite. The new plant will produce an entirely new line of J-M products for use as inert absorbents, bulking agents or extenders in paint, rubber, paper, cleansers, insecticides, fertilizers, dry cleaning, protroleum, and many other fields.

STOWE-WOODWARD

Stowe-Woodward, Inc., Newton Upper Falls, Mass., is building a new plant for the production of rubber roll coverings used in papermaking and textile finishing. Under construction at Griffin, Ga., the new plant was designed by architect, Gerald L. Bilbro of Griffin, and is expected to be completed in December of this year.



Stowe-Woodward plant at Griffin, Ga.

AMERICAN CYANAMID

The American Cyanamid Co., New York, N. Y., has established an undergraduate scholarship program under which 17 undergraduates about to enter their junior or senior year will be awarded $600 each for academic year 1954–55.

MONSANTO

The Monsanto Chemical Co., St. Louis, Mo., is producing a new size designated Mersizerm dry which is said to have the optimum degree of fortification for the highest sizing efficiency.

BLACK-CLAWSON

The Black-Clawson Co., Middletown, Ohio, has been granted patents covering the Duotrol for automatic and remote control of jordans and refiners.

SOLVAY

The Solvay Process Div., Allied Chemical & Dye Corp., 61 Broadway, New York 6, N. Y., has issued a technical and engineering service bulletin entitled "The Analysis of Liquid Chlorine and Bleach."

FIBERGLAS

The Owens-Corning Fiberglas Corp., Toledo 1, Ohio, has appointed the Certain-Teed Products Corp., Ardmore, Pa., and the Flintkote Co., New York, N. Y., as distributors for its fiberglas roof insulation.

HERCULES

The Hercules Powder Co., Wilmington, Del., has issued a technical booklet illustrating how Vinsol resin may be used to reduce the cost of phenol-formaldehyde resins.

OBITUARY

Sidney D. Wells

Sidney Deeds Wells (Retired), formerly research associate at The Institute of Paper Chemistry, died on May 16, 1954, in Washington, D. C., after a week's illness.

Mr. Wells graduated from the Massachusetts Institute of Technology in 1909. In 1909 and 1910 he was a chemical engineer for the Mead Pulp & Paper Co., Chillicothe, Ohio. From 1911 to 1925 he was an engineer at the Forest Products Laboratory and a lecturer at the University of Wisconsin, Madison, Wis., except for the years 1916 and 1917 when he was assistant superintendent and chemist for the Chesapeake Corp., West Point, Va. He was director of the Paper Mills Laboratory, Inc. from 1925 to 1930, and from 1930 to 1932 he was technical director of the Nekoosa-Edwards Paper Co. From 1932 until 1935 Mr. Wells was employed by the Combined Locks Paper Co. In 1936 and 1938 he was associated with Peter A. Paulson as a consultant for the Mine & Smelter Supply Co., Quincy, Ill., where he did much work investigating the merits of the rod mill as a unit of stock preparation equipment.

In 1938 Mr. Wells joined the staff of The Institute of Paper Chemistry as a research associate where he acquired an enviable reputation as a teacher.

Funeral services were held in Poolesville, Md., on May 19. His body was cremated. Survivors include his wife, four daughters, two sons, and sixteen grandchildren.

LOCAL SECTION ACTIVITIES

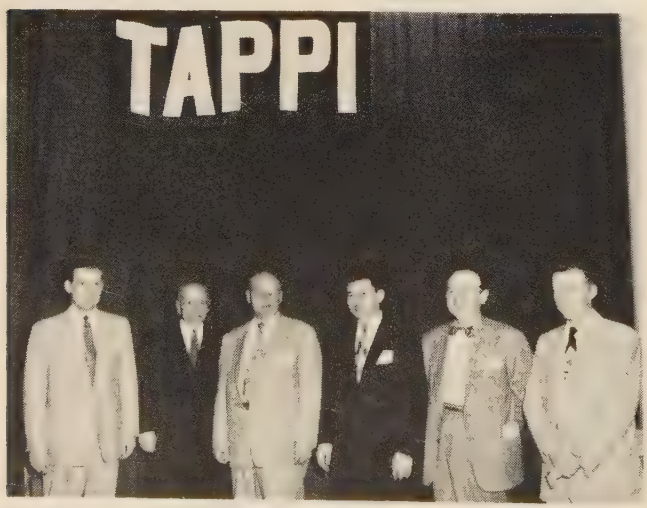
Reports of Meetings, Personnel, and Events

Chicago

W. C. Huebner, printing consultant, described his revolutionary electrostatic printer to the April Chicago TAPPI meeting on April 19. This method of printing by electronics operates at high speeds, using dye in mist form to act as ink, and eliminating plates and make-ready. Operating a laboratory in New York State for the printing industry, Mr. Huebner has been instrumental in the development of the process called electrostatic or "mist" printing.

The process was developed in conjunction with Standard Register Co., Dayton, Ohio, to deposit carbon on a thin sheet of tissue used for continuous form printing process. The discovery that an image could be printed on the web was found by accident when an early machine accidentally caught fire and smoke was fused on a tissue. When the image could not be rubbed off, the idea for the process was born. At the present time, utilizing the principle of electrostatics, the carbon is coated on the tissue by a press operating at 700 f.p.m. Plans are under way for a press that will do the same operation at the rate of 2200 f.p.m.

The electrostatic method deposits ionized particles of pigment, in mist form, on a sheet in an image pattern. The press consists of two chambers separated by a plate of special coated glass. One contains a light source and holder for the material to be reproduced. Image strikes glass on uncoated side (transparent material uses projected light; opaque, reflected). The web passes in front of the coated plate (metallic glass coating can be any one of several metals since it functions as a photoelectric cell). The second chamber on the other side of the paper contains an electrostatic grid for the charge. Electrostatic force carries the mist, from an atomizing nozzle, to the web surface in the form of the image projected. Light becomes electric energy and mist is deposited in proportion to projected light from original copy. The press offers speeds as fast as web can be driven, economy (since paper grade would be immaterial), no make-ready or platemaking, and the use of either negative or positive copy. Corning Glass has produced a cylinder that can be used for the press.



J. D. Johnson, Container Corp. of America; W. C. Huebner, E. C. Berg, Ace Carton Co.; K. Horita, F. E. Hopkins, and J. R. Lyon, Atlas-Boxmakers, Inc.

The process can be adapted to coating paper or board and has also been used to form a sheet of paper without utilizing all the water necessary in the present process. Mr. Huebner told of trials made with various firms but stated that none had as yet installed a press, some having regarded it as a laboratory curiosity. The government has, however, ordered ten of these machines for the Air Force to reproduce their drawings. When quizzed about the possibility of printing on boxboard, he stated the process should work exceptionally well, since the variation of caliper across the sheet, which causes difficulty in printing folding cartons because of the roughness of the board, makes no difference to the electronic particles in transferring the image by mist. He did state that it was necessary to control the charge, otherwise the electronic action would continue and in a thin sheet might pull the material completely through the sheet to bleed on the back.

The speaker expressed his willingness to show the process and its various applications to anyone who visited his laboratory.

Pacific

Bright sunshine, interspersed with a few downpours on the first day, welcomed the members of TAPPI and the Superintendents Association who trekked to Gearhart on the Oregon Coast for the joint meeting of these two associations, May 20–22. According to E. H. Nunn of Crown Zellerbach Corp. and W. W. Clarke of Longview Fibre Co., co-chairmen for the meeting, over two-thirds of the total attendance had registered by Thursday night. They later reported 426 attended the meeting—106 mill men and 154 suppliers and their wives.

F. J. Weleber of Publishers' Paper Co., retiring chairman for the Pacific Section of TAPPI, welcomed the men and presided over a joint session on Friday morning. Three papers were presented at this session.

Wood

Edmund Ericksen of Longview Fibre Co. discussed "A New Unit of Chip Measurement and Methods of Chip Compaction." Mr. Ericksen emphasized that with the procurement of chips by both rail and truck carriers, the need arose to establish a more uniform unit of measure and to derive a method of compacting chips to a maximum practical density. Mr. Ericksen summarized his report with the statement that practical application of compact chip loadings is a major step in the development of the chip procurement program. Better use of transportation equipment and extension of economic transportation limits should add to the future development of wood waste utilization, he said. He also mentioned the unit of measurement known as the Bdu, or the average moisture-free weight per cord of 2400 lb. He feels that this is a further contribution to a chip procurement program.

William E. Beeman of Crown Zellerbach Corp. discussed log barkers, explaining the differing needs that would influence choice of barkers. For instance, to some mills speed is the controlling factor; others find that space for reserve log storage controls the choice; and, of course, there is always the factor of personal preference. Mr. Beeman graphically described the various types of barkers on the market and gave examples of their use. He commented that use of log barkers should result in higher lumber-grade recovery, greater volume recovery, reduced saw maintenance costs, less clean-up and less dogging damage. Average savings for large mills, he

said, appear to be around $1.00 per thousand. He also mentioned the greater return because of increased chip production.

Thomas R. Miles, consulting engineer from Portland, Ore., discussed the subject of "Chips—Saws to Cars." He summarized the viewpoint of both the small lumber mills and the paper mills in the chip handling and procurement program.

Business Meeting

The two associations held their business meetings on Friday morning. Pacific Section of TAPPI elected officers for the coming year. E. H. Nunn is the new chairman; John McEwen of Scott Paper Co., vice-chairman; and H. B. Petersen of Hercules Powder Co. was re-elected secretary-treasurer. The executive committee consist of F. J. Weleber, Frank Hamilton, John L. Ayres, and B. T. Briggs.

The Pacific Coast division of the Superintendents, whose chairman is W. W. Clarke, made plans for its annual meeting which will be held in Seattle, Wash., at the New Washington Hotel, December 3 and 4.

Pacific Power

Frank M. Warren, Jr., executive vice-president of Portland General Electric Co., spoke to the men and women at the luncheon Friday. Mr. Warren emphasized that "falling water" currently is the most important and economical source of power in the Pacific Northwest. This supply is not inexhaustible, said Mr. Warren, and 10 to 15 years should see the end of that development. He mentioned that of the different sources of power, the only other one that holds promise is atomic power which, since it is now only in its developmental stage, is too high in cost to be feasible and is not an immediate source. Mr. Warren also indicated that up through 1960 power agencies should be able to take care of the normal load current, which would include medium industrial developments but no additional major industries. He further stated that by 1963–64 this area will need $13^1/_2$ million kilowatts per year. Warren was emphatic in his statements that more extensive cooperation is required on the part of the local agencies—public, private, and commercial—to do the job at hand on power development. By paying part of the cost of the dams and power projects, and reimbursing the government, paying for equipment replacement, etc., the companies would be able eventually to own the dams free and clear and be able to sell all the power. "We must approach this problem from the standpoint of getting at the job quickly and from the standpoint of cooperation," said Mr. Warren. "We cannot afford to do otherwise."

Use of Alloys

One of the key speakers at this joint meeting was Frank A. Guba, manager of research of the Carpenter Steel Co., Union, N. J. Mr. Guba addressed the general session on Friday afternoon, with Max A. Bailey of Westminster Paper Co., presiding. He discussed in detail the various alloys of the paper industry and stressed the importance of quality material in installations, thus cutting down replacement and maintenance costs. He brought out the value of more expensive, corrosion-resistant metals of less thickness than the less expensive metals which are not so durable. "We believe," he said, "that it pays to use the highest resistant alloy with the thinner wall for best economy."

After Mr. Guba's talk the men segregated themselves into three group sessions. The papermaking discussion was headed by Cecil Taylor of Columbia River Paper Mills. Thomas H. Grant of Publishers' Paper Co. presided over the acid pulping discussion, and kraft mill losses was chaired by L. D. McGlothlin of Crown Zellerbach Corp.

After the full day of meetings and group discussions, the conventioners gathered for a cabaret dinner at the hotel, which was followed by an evening of dancing.

Saturday morning everyone in the hotel was aroused by a vigilant telephone operator for the "Wake-'em-Up" breakfast. The production, "Death of a Salesman," was put on by Waiting Room No. 1 of the International Brotherhood of Migratory Peddlers. E. G. Drew of Drew Engineering Co. presided during this hiliarious entertainment. During the program W. W. Clarke was made an honorary member of the Peddlers.

General Session

The men joined in a general session on Saturday morning, which included papers by W. W. Clarke, Gus Ostenson of Crown Zellerbach Corp., and C. C. Heritage of Weyerhaeuser Timber Co. Mr. Clarke, who discussed "Hot Pressing on Paper Machines," covered the general theories of the effect on viscosity of raising temperatures up to the neighborhood of 160°F. and gave in detail the experience of Longview Fibre in doing this on a paper machine in their mill. He related the various advantages and problems that were encountered in this process.

Mr. Ostenson spoke on the "Effective Use of Man Power," tying in his remarks with the system used at his Camas mill. He explained the division of responsibility and the definite lines of responsibility for the various jobs in the paper mill. Mr. Ostenson told how responsibilities are broken down for the superintendents and the assistant superintendents and how the chain of responsibility is established. His talk was amply illustrated by job analysis charts and graphs.

During the convention, representatives from the Pacific Sections of TAPPI, the Superintendents and the Technical Section, Canadian Pulp and Paper Assn., drew up preliminary plans for a Tri-Way meeting that is to be held at the Empress Hotel in Victoria, B. C., May 18–21, 1955. The three cochairmen appointed are Max A. Bailey for the Superintendents; E. H. Nunn for TAPPI; and Louis Pumphrey, Westminster Paper Co., for the Canadian Technical Section.

On Friday, the women had their golf tournament in the morning and were entertained by a tea and fashion show in the afternoon. Mesdames W. W. Clarke, E. H. Nunn, Max A. Bailey, J. B. Beck, and J. M. Victor poured at the tea. On Saturday afternoon, Mrs. E. H. Nunn presided at a ladies' luncheon at the hotel.

In the evening the men and women joined forces for the get-together party, sponsored by the Industrial Affiliates and the allied industries. Hugh Osborn, Pacific Coast division industrial affiliate representative, was in charge of the party. An informal banquet and dance wound up the planned festivities of the convention. H. A. "Gob" DesMarias of the Geigy Chemical Co. was master of ceremony for the banquet. During the banquet Fred C. Ihlenberg of the National Aniline Division, chairman of the golf tournaments, announced the winners for both the men and women. W. W. Clarke and E. H. Nunn were complimented on their good work on the convention and they in turn introduced all the committee members and those who had participated.

Paper Trade Journal

Lake States

The last meeting of the Lake States Section of TAPPI for the 1953–54 season was held at the Stevens Point Country Club, Stevens Point, Wis., on May 11, 1954. About 40 of the members played in a golf tournament in the afternoon. This was followed by a cocktail party sponsored by the affiliates group. An excellent dinner was served in the club dining room with about 90 in attendance. Chairman R. J. Seidl presided at the meeting following the dinner. The election of the following officers for the 1954–55 season was announced:

Chairman: L. A. Moss, Whiting-Plover Paper Co., Stevens Point, Wis.

Vice-Chairman: S. R. Parsons, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
Secretary: John W. Bard, Marathon Corp., Menasha, Wis.
Treasurer: S. J. Baisch, Thilmany Pulp & Paper Co., Kaukauna, Wis.
Executive Committee: K. A. Craig, Kimberly-Clark Corp., Neenah, Wis.; Fred Herbolzheimer, Jr., Marinette Paper Co., Marinette, Wis.; J. M. Holderby, Rhinelander Paper Co., Rhinelander, Wis.; J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.
Retiring Chairman: R. J. Seidl, Forest Products Laboratory, Madison, Wis.

After the dinner a very pleasant hour was spent with entertainment provided by the Wausau Fun Band.

S. R. Parsons, *Secretary*

Empire State (Eastern District)

At the final meeting of the year for the Eastern District, Empire State Section of TAPPI, Ladies' Night was observed. This was held at Milfranks on the Lake George Road, Thursday evening, May 20, at 6:30 p.m.

The General Electric "House of Magic" show was the featured entertainment, along with dinner music by Ray LaFarr and his accordian, and comedy pantomime by the Panoramics. An orchestra furnished music for dancing.

Officers for the coming year were elected as follows: Grant Cole, chairman; Earl Johnson, vice-chairman; Karl Kroetz, entertainment committee chairman; Clyde Davis, treasurer; Richard J. Collins, secretary; Talmadge Edman, publicity committee chairman; and Vincent Long, program committee chairman.

Hugh Lavery was the chairman of the Nominating Committee.

Allen A. Lowe, *Publicity Chairman*

Empire State (Western District)

The Western District of the Empire State Section of TAPPI's annual Ladies' Night was held at the Park Hotel, Lockport, N. Y., on May 6, 1954, with 87 members and their wives present.

A colored movie, "Beauty by the Yard," and a talk were presented by W. S. McClintock of Armstrong Cork Co.

The annual business meeting was held, and the following officers for the 1954–55 season were elected:

Officers for Western District for 1954–55

Chairman: James J. Forsythe, International Paper Co.
Vice-Chairman: Robert H. Zinsmeister, Kimberly Clark Corp.
Secretary: H. Elroy Lindbert, Robert Gair Co.
Treasurer: Ernest F. Andrews, International Paper Co.

Program Committee

Chairman: Paul U. Bretschger, Buffalo Electrochemical Co.
Vice-Chairman: Harry B. Hulse, Upson Co.

Publicity Committee

Chairman: Oscar Anderson, Jr., International Paper Co.
Vice-Chairman: Robert Hoffman, National Aniline Co.

Arrangements Committee

Chairman: George Norton, George Irish Paper Co.
Vice-Chairman: Robert Driscoll, International Paper Co.

Attendance Committee

Chairman: Charles Raleigh, Buffalo Electrochemical Co.
Vice-Chairman: Fred Rosebush, Buffalo Electrochemical Co.

Membership Committee

Chairman: Gordon K. Storin, Niagara Alkali Co.
Vice-Chairman: Fred Heil, Lockport Felt Co.

Music for dancing was provided following the business meeting.

O. E. Anderson, Jr., *Publicity Chairman*

Empire State (Metropolitan District)

About 90 members and guests were present at the May 11, 1954, Ladies' Night of the Metropolitan District—Empire State Section of TAPPI at Fraunces Tavern in New York City. A special tribute was paid and a number of gifts presented to Ralph Kumler, the present district chairman who is retiring from the American Cyanamid Co. this July.

The new chairman of the Metropolitan District, Jack Rice of the Lowe Paper Co., announced the following committee appointments:

Program Committee: Warren Beman, Socony-Vacuum Oil Co.
Membership Committee: Patrick Palmaccio, Gibraltar Corrugated Paper Co.
Publicity Committee: Louis Georgevits, Titanium Pigment Corp.

Miss E. P. Nuttall, associate editor of the *Paper Trade Journal* spoke on "The Nation's Fifth Industry—Its Marvelous Expanse and Unexplored Domains."

A sound movie entitled "Life with Paper," based on the Paper Week TV show of the American Cyanamid Co., was also shown.

L. E. Georgevits, *Publicity Chairman*

The Nation's Fifth Industry—Its Marvelous Expanse and Unexplored Domains

Elce P. Nuttall

It is of course impossible to cover a book-length subject about the vast expanse of our industry now and tomorrow in a brief address. I do want to have you sense the immensity of this growing industry. If I can stir you to excitement about its future domains, also, I shall be glad.

There is no further need for doubt that paper and paperboard is now the Nation's fifth industry. According to figures just received from Washington in the Annual Survey of Manufactures, 1952, paper and board mill products displaced cotton broad woven fabrics during 1951 by $367 million. The total for paper and board was $4,057,587,000, for cotton woven broad fabrics, $3,690,853,000. The 1952 figures were somewhat lower because of inventory adjustment throughout the economy; but paper and board still exceeded cotton broad woven fabrics by $302 million, and was exceeded in value of shipments only by motor vehicles in first position; wholesale meat packing in second; steel works and rolling mills, third; petroleum refining in fourth. Cotton woven broad fabrics was in sixth place during 1951, in seventh in 1952, paper and board mill products in fifth. This compares with 1947 totals of $3,294,623,000 for cotton woven broad fabrics, and with $2,812,048,000. It is expected that paper and board will considerably widen this gap during the industry's peak year of 1953.

As the fifth industry of the world's No. 1 power, the paper and board must accept responsibility for its contribution to the stability of the national economy. It can never ignore the well-being of the 268,737 primary paper and board mill workers and their estimated 786,563 dependents; or the 200,000 wage-earners directly employed in forestry; an equal number of part-time workers; 1516 graduate foresters and 3224 nontechnical helpers and their families, which according to American Pulpwood Assn. make up the pulpwood industry of the United States. Add to these totals, the other paper and allied products workers engaged in converting operations and in wholesale distribution, plus their dependents, and the industry's responsibility is probably close to 5 million persons in this country alone. In 488 towns in the United States

Elce P. Nuttall, Associate Editor, *Paper Trade Journal*, New York, N. Y.

th a population numbering close to 27 million, an estimated)% of the population are primary paper and pulp industry rkers and their dependents.

We can never lose sight of the fact that at this crucial point the World's history, too many have forgotten that people d their development are our first concern. All else is a rt of our provision for their food and well-being as well as our own enjoyment of life.

The pulp, paper, and board industries will grow as they ly serve the 162 million persons in the United States. r the well-being of the individual was the country founded. r their four freedoms, the free nations of the world contend. f the people, by the people, for the people" is more than a ilosophy to which we are dedicated; it is the hope of en- ved people all over the world.

Through pulp, paper, and board, this nation of ours is tied most of the nations of the world. Through pulp and paper orts, this industry has a market in 75 countries.

On the north, our bond with the great Canadian dominion is ongest through pulp, pulpwood, and newsprint imports. most we think of Canada as one with our own vast indus- .

For the countries south of us—Mexico, Brazil, Venezuela, l other of the South American countries, developing paper lustries are of extreme interest to us. Not only are their tural developments important to the peace of the world, t sanitary paper usage contributes to their health.

Currently, we are shipping the Argentine some 50,000 tons American and Canadian wood pulp. Because of currency iculties between Sweden and Argentina, North American p mills are supplying this tonnage; Sweden lost it. Ar- tina also is important to us as a casein source; the United tes paper and board industry consumes most of that ntry's casein output each year.

Sweden on the other side of the world is selling wood pulps us, to most world markets, and also to the Soviet in a new de agreement. Finland is selling to us as well as Russia, an, and much of Europe. Norway, too, is an international p trader with a stake in our market.

Thus paper and board are international ties which circle the ld with book, printing, and other fine papers; sanitary ues, packaging papers, multiwall sacks and container rds; waste papers, cotton cuttings, to mention a few.

CONSERVATION OF NATIONAL RESOURCES

As an industry, we are responsible for the conservation of national resources. Let none here feel less than proud of at has been accomplished by its forestry programs.

United States forests make up less than 10% of the earth's st area. They cover about 624 million acres. Merged o one continuous woodland, this forest area would cover all states east of the Mississippi River plus Kansas and usiana.

About three fourths of this acreage is capable of producing ber for commercial use. The remainder is either inac- ible or is reserved for noncommercial purposes, or does not duce commercial quality timber.

Provided these acres are managed properly and their prod- s produced wisely, it is generally agreed by forestry rces that these 461 million acres of productive timberlands adequate to supply the nation's requirements.

Each year new wood growth of all sizes equals 98% of that oved or destroyed, compared with the record of 25 years when $4\frac{1}{2}$ times as much wood was removed as was wn.

Nearly $17 million was spent in 1949 on forest research, % of which amount came from industries, states, private itutions, colleges, etc.

Under the "Growing Their Future" plans sponsored by st industries, tree farms embrace nearly 29 million acres in 63 states involving 5000 woodland owners growing trees as a crop.

Technical assistance to small land-owners is an expanding activity of the forestry program, and over 1 million non-farmers who own 122 million acres of woodlands are thus aided in wise cutting and conservation.

In true conservation—which means whole-log use—and tree-farming lies the forest industry's practical answer to its critics and skeptics who have cried "waste and timber famine" in bygone days, J. P. Weyerhaeuser, Jr., president of Weyerhaeuser Timber Co., told Forest Products Research Society a week ago.

"We are closer than many of us dared hope, and far closer than our critics have admitted, to the day when all the forest products that our dynamic, growing economy demands can be met from our current forest growth," he said.

Tree plantings and reseeding programs also are of a magnitude hitherto undreamed of. An example of this is seen in the Brown Co. announcement that nearly 150,000 baby trees have been distributed so far this year to pulpwood producers on a tree-for-tree basis. A total of more than a half-million baby trees have been distributed since this program was introduced in the Berlin, N. H., area by Brown Co. It is estimated that 500,000 acres of either public or private lands were so planted in 1952.

1953 WOOD CONSUMPTION

These are the lands which grow most of the 28,150,348 cords of pulpwood consumed during 1953—one half of which was pine, one third other softwoods, one-seventh hardwoods. Canadian imports are estimated at 1.5 million cords. Add to this total the pulpwood which produced 543,000 tons of overseas pulps which United States consumers bought during 1953—or approximately 951,000 cords, and the gross total pulpwood consumed is close to 29 million cords.

Since all pulpwood at one stage or another moves on trucks, and figuring 3 cords to the truck, it would take 9.7 million trucks to load last year's pulpwood consumption. Spaced 100 ft. apart, means 970 million ft. of trucks, or 185,000 miles of trucks. Since the world's circumference at the equator is 24,902 miles, we should have a belt of pulpwood trucks $7\frac{1}{2}$ times around the world carrying last year's consumption of pulpwood by United States' mills.

From these 29.1 million cords of pulpwood were produced the 18,681,713 tons of wood pulps consumed by American paper and board mills in 1953. To this tonnage, add waste paper salvage of 8,530,671 tons—which it is estimated would equal the cut from a forest area the size of the New England states; plus approximately 1.2 million tons of straw, rags, cotton fiber, manila stock, and other fiber; and we have the fibrous materials which produced the 26,566,356 tons of paper and board during the peak year of 1953.

Based on 1953 consumption of 31.1 million tons, the per capita is 392.4 lb., a phenomenal figure when compared with per capita use of sugar at 97, meat 148, flour 135, vegetables 26 lb.; or with industry figures of earlier decades.

Paper and board per capita in 1929 was 220.2, in 1919 it was 119.6, and in the year 1898, 58 lb.

Rated against per capita usage in other world areas during 1950 when the United States figure was 382.5, Canada stood second with 260.4, the United Kingdom was third with 133.3, Denmark followed with 131, New Zealand 124.4, Iceland was 109.9, the Netherlands 108.4, Switzerland 104.8, countries of Northern Europe grouped were 101.9, Continental Europe averaged only 42.5—drawn down by the lows of Rumania with 6.8, Canary Island 7.9, and many others in like brackets. Australia averaged 63.5; Central and South America 17.1, Africa 6.5, Asia 3.3, Near East 2.7. World lows were British East Africa and Tagoland at 0.4 pound, Mozambique 0.3, Indonesia at 0.5, Arabia 0.6, Indo-China 0.7 lb. per person.

PAPER AND BOARD PRODUCTION, 1953

Paper and board products today number well into the hundreds of varieties with more reaching the market daily. The volume of last year's output of 26.5 million tons is more readily grasped if we think of it loaded into railroad box cars. It would take the entire box-car equipment of the United States railroad system—which Louis T. Stevenson rates as 689,793 serviceable cars as of March 1—almost one and a half days to move this annual mill production—converted products excluded. Figuring annual consumption of over 31 million tons, it would take 1,150,000 box cars to move it.

This takes no account of incoming freight which is rated about five times the tonnage of the outgoing.

MARKETS

Like America's industrial production, the growth performance of the United States paper and paperboard industry is often looked on as a miracle and a breath-taking wonder. The industry's optimistic appraisal of yet unexplored dominions makes one wonder whether paper and board men are either deluded or misled by daydreams.

Paper industry optimism is born of self-confidence backed by a wealth of mental and physical energies, and the assurance that, with the sole exception of printing materials, paper usage by general industry and the home is still in its infancy.

Its recognized use, for instance, as sanitary tissue is very moderate in lower-income families. Television, radio, and other advertising forms are educating the American family to the convenience, hygiene, and economy of towels, tissues and napkins, diaper inserts, toilet bowl mops, garbage bags and disposal units, refrigerator and deep-freeze food containers, and other uses *ad infinitum*.

New packaging ideas, display boxes, fiber boxes designed to sell more merchandise; stronger fiber boxes constructed to supplant wooden crates and cut down on freight costs; new book enamels, duplicating papers, napkins, gummed tapes, towels, and tissues are being marketed. Fertile boxboard minds have even devised a "cat castle" as a home for the family pet. Equipped with easy entrances and exits, it is a companion piece to the proverbial doghouse.

Most productive of the industry's markets, and possibly the most profitable are those where paper and paperboard supplant traditional materials. Multiwall sacks, for example, are more than a replacement for cotton and burlap. They are a custom-built protective packaging for hundreds of commodities. Fiber drums and fiber boxes supersede metal and wooden containers. Each is engineered for better packing, maneuverability, and less shipping costs. New building paper and boards are more than a makeshift for wood and metal. They provide forms which, because of light weight, adaptability and lower cost open up spheres of usefulness hitherto unexplored.

Outstanding in this field is paper honeycomb, the sandwich core material of kraft which can be expanded to produce a large-volume, low-density sandwich structure. The uses of this man-made timber appear to be limited only by man's ingenuity. Structural fields alone offer infinite possibilities, and new applications are being conceived daily. Paper honeycomb could well become an industry major.

Even in spheres where paper and paperboard usage have general acceptance, growth is being forced on the industry by new social patterns growing out of the daily round of activities in the American home.

A leading element in this trend is the vast army of women who occupy career and industry jobs. Now numbering over 12 million, these women seek short cuts in food preparation and service, laundry, and general homemaking. To meet these demands, frozen foods, precooked meals, paper napkins and towels, paper cups and plates, and no-iron fabrics are a *must*.

Frozen foods mean deep-freeze units and wrapping materials. Year-around availability of fruits and vegetables, fish, flowers, hitherto looked on as seasonal items, is now possible because of paper and board packaging for their ar travel at freight savings.

Heightened emphasis on hygiene means higher standards of cleanliness in the school, hospital, and industry, and wide acceptance of paper in milk containers for the home, as for the school lunch program; cup and plate service in schools, hospitals and industrial in-feeding; 1 billion cups for coffee service; 2 billion cups for soft drinks; 3 billion cups in vending machines; 2.5 million tons of special food board produced last year, for a gain of 65,000 tons over 1951's high. Sanitary tissue output in 1953 totaled 1,255,081 tons, compared with 1,243,858 tons in the industry's peak year of 1951.

Because of higher freight costs, fiber drums and boxes show staggering gains in moving foods, chemicals, and various unexpected commodities. Compared with the 3.5 million fiber drums produced in 1940, the 1952 record was 24.4 million units produced by 24 plants. The 1953 record was an all-time high that covered volatile corrosion inhibitors for metal products, desiccants, as well as the cooking compounds, dehydrated vegetables, milk solids, vitamins, and the usual chemicals.

Kraft cord—a plasticized twisted kraft yarn—is just making an entry into the field of textiles. As a rug backing in natural color, it provides a clean uniform, stable fiber that is displacing jute. In plaid and color combinations, its use as automobile seat-covers and trunk-liners is widening because it is washable, cooler, nonabrasive, nonshock, nonravel, and less expensive than the textiles it supplants. As bus upholstery, it serves similarly and has the additional feature that it can be rewoven.

As a woven wall covering, it is available in colors which can be washed, that are abrasion and stain resistant, fire retardant and nonravel. What's also important, the costs of installation are a fraction of the high-cost grass cloths.

For hats of Tex-straw that are termed water-repellent, ventilated for comfort and nonabrasive; for shoes, swim suits, purses, walking shorts, beachrobes, cabanas, lamp shades, bridge-tables and chairs, the use of kraft cord is assured. Research men say this is only the beginning of paper's move into the textile field; we are yet in the horse and buggy stages.

Paper tiles are another whole world in which paper usage is hardly known. A weld of kraft paper and resin, plastic surfacing is available in an extensive range of colors and finishes which simulate woods, textiles, pearl lusters and which blend with modern or traditional decor. In thicknesses for vertical or horizonal surfacing, they are sun-fast, heat resistant, washable, and long-lived.

FUTURE

The future of paper may well be assured by our population growth. But research and production men, as well as sales executives, dare not overlook the blantant fact that this is a buyer's market. According to Commerce Department findings, the consumer has dollars to spend and she is buying services rather than goods.

We have pulp, paper, and board capacity not being consumed. Let's face up to two things: (1) we must merchandise what we want to sell her, and (2) what is extremely important on such a market, if we would catch it at flood-tide: let's find out what Mrs. Consumer wants and give it to her.

Seneca had it that it is the duty of every man to make himself profitable to mankind. The United States paper and paperboard has grown because of its service to the people. "Fifty million Frenchmen" could be wrong, but 162 million Americans and succeeding generations with advancing standards of living cannot fail to force our industry into an era of prosperity of which today is a foretaste. Opportunity, it has been said, is the flower of time. Let's use it well.

Dextrinizing Value of Enzymes (Enzyme Activity)*

TAPPI Suggested Method T 643 sm-54

(THIS SUGGESTED METHOD IS UNDER THE JURISDICTION OF THE NONFIBROUS MATERIALS TESTING COMMITTEE)

Amylolytic enzymes are widely used to modify tive starches and reduce their viscosity. In use, the zymes are added to a starch-water slurry and the xture heated during a controlled time-temperature le. In general, the enzyme works best at a pH be- een 6.5 and 7.3. The conversion temperature may y from 150 to 175°F., depending on the starch used. prevent continuing action of the enzyme, inactiva- n is necessary when conversion is completed. This y be done by bringing the cook to a boil or by the use hemicals such as lead or copper salts.

The commercial enzymes used for the modification of rch in the paper industry are generally alpha- ylases of microbiological origin. These enzymes are d in the form of liquids or solids which are dispensed capsules, pellets, concentrates, or bulk powders.

The assay method herein described measures the dex- hizing value (DV) of amylolytic enzymes and is erally referred to in the industry as an alpha-amylase trinizing method. The method is designed especially enzymes of nonmalt origin, particularly bacterial. has been found that excellent correlations exist be- en the DV potencies of this group of enzymes and ir empirical uses in the paper mill. Correlations of DV method with starch liquefaction tests by the osity method have been excellent.

Regardless of the form in which the commercial en- ne is purchased, it is necessary for the analyst to pare an extract of the enzyme sufficiently diluted to e an activity which falls in the proper range. The strate used is 2% Lintner starch rather than "limit trin" (SKB method) (*1*). Since "limit dextrin" is Lintner starch which has been reacted with an ex- s of malt beta-amylase, it is believed that the analy- of samples which are of nonmalt origin and rich in ha-amylase becomes unnecessarily complicated by reaction with malt beta-amylase. The use of starch lf has, therefore, been selected as the substrate.

ote: The method requires a primary standard of known DV ncy which is obtained by either of the following: (1) primary dardization by means of the visual calibration procedure de- ed under the section Calibration of Photometer, or (2) use of a standardized enzyme preparation of known DV potency obtained from an approved source.

This method is suggested by the Standards Committee as being the most ble to date. It is *not*, however, a TAPPI Standard. Criticisms are ear- y suggested and should be sent to R. G. Macdonald, Secretary, Technical ciation of the Pulp and Paper Industry, 155 E. 44th St., New York 17.

DEFINITION

One DV unit represents the enzyme activity equivalent to the dextrinization of 20 mg. of Lintner starch in 30 minutes at 30°C. and pH 6.6. It is reported as DV per gram of sample.

APPARATUS

1. *Evelyn Photoelectric Colorimeter*, using 660-millimicron filter (Rubicon Co., Philadelphia, Pa.).
2. *Test tubes for photometer.* Matched tubes, calibrated at 100 ± 0.5% transmission with distilled water.
3. *Constant-temperature bath*, capable of being maintained at 30 ± 0.1°C.
4. *Serological pipet*, 5-ml., graduated in 0.1-ml. intervals to tip. For adding diluted enzyme solution to starch solution.
5. *Pipet*, 1-ml., Ostwald-Folin, blow-out type. For adding enzyme-starch mixture to the iodine solution.
6. *Transfer pipets*, 10-ml.
7. *Volumetric flasks*, 100, 250, 500, and 1000-ml.
8. *Iodine storage bottle*, of amber glass.
9. *Stirrer.* Electric, or air.
10. *Interval timer*, or an electric wall-type clock with sweep second hand.
11. *Pyrex beakers*, 50-ml., for weighing samples.
12. *Hellige Comparator*, with Alpha-Amylase Color Disk and 13-mm. tubes (*2*). Color disk 620-S5 comparator and 13-mm. square tubes are available from Hellige, Inc., 3718 Northern Blvd., Long Island City, N. Y.

REAGENTS

A. *Starch Solution*, 2%. Prepared from Lintner starch (Merck) as follows: To 375 ml. of boiling water (*see* Note) in a liter beaker add the equivalent of 10 grams of moisture-free Lintner starch in the form of a thin paste, at such a rate that boiling is maintained. Keep the solution well stirred by means of the stirrer. After all the starch has been added, maintain stirring and boiling for an additional 5 minutes to complete the

solubilization. Should the solution have a tendency to boil over, add a few ml. of water from a wash bottle occasionally and/or lower the flame. After the 5-minute heating period, add 50 ml. of water and transfer to a 500-ml. volumetric flask. Stopper and cool to approximately 30°C. Add 10 ml. of pH 6.6 buffer and dilute to the mark. This solution must be made up fresh daily.

Note: Wherever water is mentioned in this method, it refers to distilled water.

B. *Buffer Solution*, pH 6.6, prepared as follows:

(a.) Sorenson's primary phosphate, $M/15$. Dissolve 9.078 grams of KH_2PO_4 in water and dilute to 1 liter.

(b.) Sorenson's secondary phosphate, $M/15$. Dissolve 11.876 grams of $Na_2HPO_4 \cdot 2H_2O$ in water and dilute to 1 liter.

(c.) Mix 600 ml. of primary (a) and 400 ml. of secondary (b) to obtain pH 6.6.

C. *Iodine Solution*

(a.) Stock. Dissolve 11 grams of KI and 5.5 grams of iodine in about 200 ml. of water in a 250-ml. volumetric flask and dilute to the mark. Store in a stoppered amber bottle under refrigeration, where it will keep indefinitely.

(b.) Working solution. Transfer 4 ml. of the stock solution to a liter volumetric flask containing 40 grams of KI dissolved in water, and dilute to the mark. Store in a stoppered amber bottle under refrigeration. This solution will keep for 1 month.

CALIBRATION OF PHOTOMETER

The photometer used must first be calibrated with an enzyme preparation of known potency. A DV determination using the visual dextrinizing end point and the Hellige Alpha-Amylase Color Disk and 13-mm. comparator tubes (*2*) is described below.

Note: If desired, a DV standard enzyme can be obtained for calibrating the photometer from the Pabst Laboratories, Milwaukee 3, Wis. Use of this greatly simplifies the procedure by eliminating the need for determining the DV of the standardizing enzyme.

To determine the DV, digest at 30°C. 10 ml. of 2% Lintner starch (200 mg.) and 5 ml. of the standardizing enzyme which has been diluted with water to the proper concentration based upon its expected DV value (Table I). Determine the dextrinizing time (DT) in minutes by removing at intervals of 0.5 minute 1 ml. of the digesting mixture, mixing with 5 ml. of dilute iodine solution, and immediately transferring to the 13-mm. square tube of the Hellige Comparator. The end point is obtained when the color matches that of the color disk in the Comparator. For accuracy and convenience, the dextrinizing time should fall within 10 to 30 minutes. If necessary, use more or less enzyme to increase or decrease the dextrinizing time until it falls within this range.

Calculate the DV units per gram by the formula:

$$\text{DV units per gram} = \frac{60DF}{DT}$$

in which the dilution factor (DF) is the total volume in milliliters to which the sample of enzyme is diluted, divided by the weight of the enzyme in grams.

Note: The formula is derived as follows: By definition, 1 DV unit dextrinizes 20 mg. of starch in 30 minutes, or 200 mg. (10 ml. of 2% starch slurry) in 300 minutes. The number of DV units in the 5-ml. aliquot is therefore 300 divided by DT. The weight in grams of the enzyme sample in the 5-ml. aliquot is 5 divided by the dilution factor DF. Hence,

$$\text{DV per gram} = \frac{\text{DV units in 5 ml.}}{\text{Grams of sample in 5 ml.}} = \frac{300}{DT} \div \frac{5}{DF} = \frac{60DF}{DT}$$

Table I. Dilutions

For obtaining an end point within the recommended range of galvanometer readings, the following table shows convenient dilutions for enzymes of various approximate DV values; the final enzyme solutions will contain approximately 4 DV units per ml.

Approximate DV of enzyme	*Weight of enzyme in grams diluted to*			
	100 ml.	*250 ml.*	*500 ml.*	*1000 ml.*
100	4.0	10.0	20.0	40.0
200	2.0	5.0	10.0	20.0
300	1.3	3.3	6.6	13.3
400	1.0	2.5	5.0	10.0
500	0.8	2.0	4.0	8.0
600	0.67	1.7	3.3	6.7
700	0.57	1.4	2.9	5.7
800	0.50	1.3	2.5	5.0
900	0.44	1.1	2.2	4.4
1000	0.40	1.0	2.0	4.0
1200	0.33	0.8	1.6	3.3
1400	0.29	0.7	1.4	2.9
1600	0.25	0.6	1.3	2.5
1800	0.22	0.55	1.1	2.2
2000	0.20	0.50	1.0	2.0
2500	0.16	0.40	0.8	1.6
3000	0.13	0.33	0.67	1.3
4000	0.10	0.25	0.50	1.0
5000	0.08	0.20	0.40	0.8
6000	0.07	0.17	0.33	0.67
7000	0.06	0.14	0.27	0.57
8000	0.05	0.13	0.25	0.50
9000	0.04	0.11	0.22	0.44
10000	0.04	0.10	0.20	0.40

For samples having DV values above 10,000, it is recommended that a secondary dilution be made to obtain approximately 4 DV units per ml.

After having established the potency of the standardizing enzyme, calibrate the photometer by relating galvanometer readings to DV units for the 20-minute digestion time. With the Evelyn Photometer using $^7/_8$-inch test tube cells, a straight-line relationship exists over a range of 10 to 75 galvanometer units, corresponding approximately to 13 to 18 DV units per 5-ml. aliquot of enzyme solution. Follow the procedure below for Analysis by Photometric Method, using amounts of enzyme such that the DV is between 13 and 18 DV units per digestion tube. Plot a standard curve or prepare a table relating DV units per tube to galvanometer reading. This plot or table is then used as described below for determining the potency of unknown enzyme samples from galvanometer readings.

Note: Whenever a new lot of starch is used, a new standard curve should be prepared.

ANALYSIS BY PHOTOMETRIC METHOD

With photometers it has been found that in the region of the dextrinizing end point there is a linear relationship between enzyme concentrated and galvanometer deflections of the photometer. It is thus possible to fix time constant, 20 minutes being selected, and take only one reading per sample. This permits analysis of many samples with precision in a short time. However, in cases where a photoelectric colorimeter is not available and time is not too great a factor, a Hellige Comparator may be used in accordance with the technique described above under Calibration.

Preparation of Enzyme Solution

From the expected potency of the sample, and using Table I, select a sample weight which, when diluted, will have approximately 4 DV units per ml. Weigh the sample into a 50-ml. beaker on the analytical balance to the nearest 0.1 mg., transfer quantitatively to a volumetric flask, and dilute to the mark.

Setting of Photometer

Insert the 660-millimicron filter, set at 100% transmission with water and record the "center setting." Adjust to this center setting between readings.

Procedure

Warm about 30 ml. of the diluted enzyme sample in a test tube in the 30°C. bath. Transfer 10 ml. of 2% starch solution to the bottom of four 25 by 150-mm. test tubes; avoid wetting the walls. Add a volume of water to each tube, such that the total added volume together with the enzyme solution to be added later is 15.0 ml.

Based upon the expected potency of the sample, calculate the increments of enzyme solution in ml. which will furnish a range of 13 to 18 DV units per digestion. (After experience with the method only two or three tubes are necessary.) This volume used should be from 1 to 5 ml. Set the tubes in the 30°C. bath for 5 minutes to come to temperature. At 1-minute intervals, add the increments of enzyme solution to their corresponding tubes, mix by shaking, and replace in the bath. At the end of 20 minutes, remove a 1-ml. aliquot from each tube with the blow pipet, add to 10 ml. of diluted iodine solution in a $^7/_8$-inch absorption tube and mix by shaking. Read per cent transmissions in the Evelyn Colorimeter with the 660 filter after setting the instrument at 100 with water. Readings which are beyond the 10 to 75 range shall not be used. Transmission readings shall be made within 60 minutes after color development.

REPORT

Report the enzyme activity of the sample as dextrinizing value (DV) per gram, calculated to the nearest whole unit if less than 1000, otherwise to the nearest 10.

Example of Calculation

A 1.0189-gram sample with an expected potency of 1000 DV units was diluted to 250 ml.; 1 ml. = approximately 4 DV units. (Dilution factor = 250/1.0189 = 245.36.) The following data were obtained:

Tube ⟶	1	2	3	4
2% starch solution, ml.	10	10	10	10
Water, ml.	0	0.6	1.2	1.8
Diluted enzyme, ml.	5	4.4	3.8	3.2
Galvanometer reading	83.50	67.25	43.00	14.00
DV units per digestion (from standard curve)	19.27[a]	17.80	15.62	13.01
DV of original sample[b]	...	993	1009	998

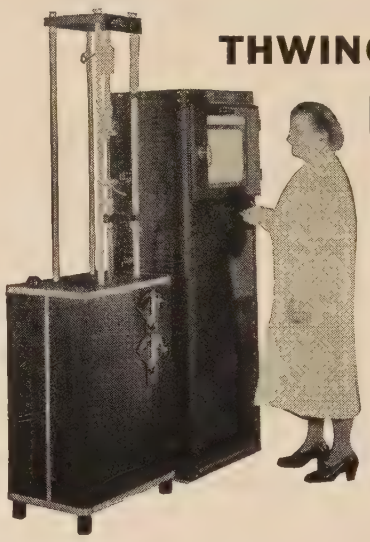
[a] Outside of allowable limits.

[b] DV per gram = $\frac{250 \text{ (DV per digestion tube)}}{1.0189 \text{ (ml. diluted enzyme per tube)}}$

Average DV = 1000.

LITERATURE CITED

1. Sandstadt, Kneen, and Blish, *Cer. Chem.* 16: 712 (1939).
2. *Am. Soc. Brewing Chemists Proceedings* 1949: 169–171.



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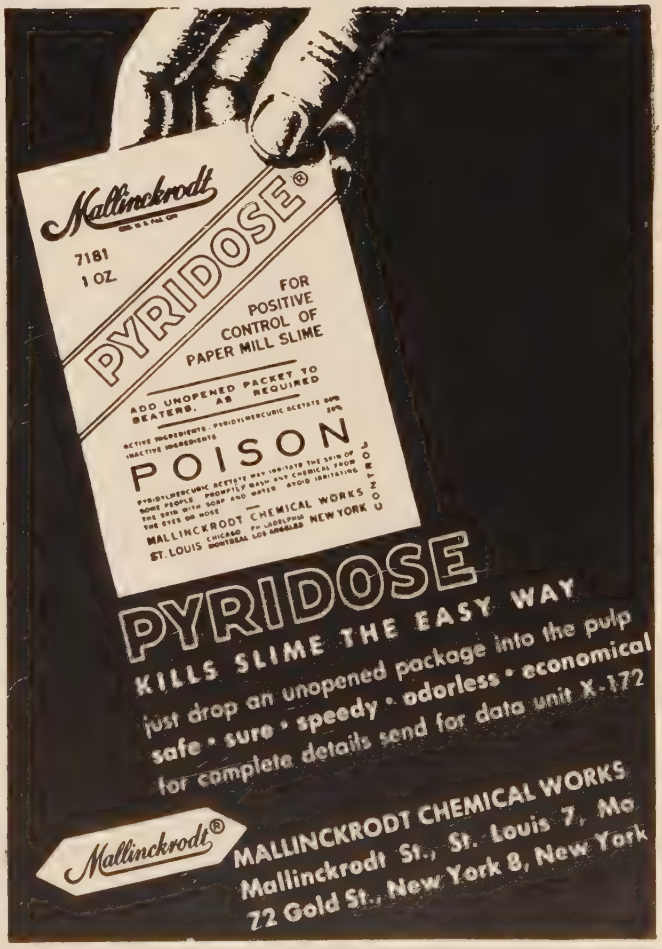
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Electrical System Grounding

G. P. HOBBS and R. H. KAUFMANN

ELECTRICAL failures in motors and circuits are occurring in the paper industry. Although not numerous, they occur far more often than should be expected. The reasons for failures are not fully understood.

Repeatedly the findings are as follows. Electrical insulation (except at the local spot marking the failure point) appears to be sound and in serviceable condition. The general environment is not bad except for the nearby presence of water in some areas. The AIEE proof high-potential test following manufacture tends to rule out hidden internal defects. Yet failures do occur sometimes after no more than a year or two of active service. Why?

These observations are not unique to the paper industry. However, it is the paper industry with which we are concerned at this time. The general prevalence of water around mills is a decided factor.

Time after time, the circumstances suggest overvoltage as a possible factor. Overvoltages may be regarded as a certainty when multiple simultaneous breakdowns take place. Lightning might be the offender although in many, many cases it can be positively ruled out. No, lightning is not the explanation.

With characteristic inquisitiveness, the electrical engineer undertook to find the explanation. What is the cause or causes of these premature electrical breakdowns? If overvoltage is a factor, where do such overvoltages come from and how might they be eliminated?

From an intensive study by many analysts, which extended over a good many years, came the discovery that damaging overvoltage can be created in a number of different ways under the most innocent appearing conditions. It develops that the ungrounded electrical system is much more susceptible for two major reasons.

First, the ungrounded system, having no intentional connection with ground, readily assumes whatever potential to ground that may be impressed on it. For example, should one phase wire of a 4160-v. system fall into the conductors of a 480-v. ungrounded system, these low-voltage conductors would simply assume a potential of 2400 v. to ground.

Secondly, the capacitive coupling to ground (which is an inevitable property of an ungrounded system) can be the very element responsible for the creation of overvoltages. The essential elements of the electrical circuits involved are shown in Fig. 1. Dangerous overvoltages can be developed by two distinctly different mechanisms, the first resulting from a high reactance fault from line to ground due to series resonance and the second simply the result of a repetitive momentary contact fault connection from line to ground.

OVERVOLTAGE DEMONSTRATOR

A detailed review of the mechanisms involved in overvoltage creation would be needless repetition. The subject was covered in an AIEE conference paper presented in Montreal in 1951. Since then the subject material has been widely publicized. Instead, it is proposed to actually demonstrate the creation of overvoltages using a miniature circuit powered from the lighting circuit. The physical make-up of the overvoltage demonstrator is illustrated in Fig. 2. Provision is made for establishing a single line-to-ground fault connection through resistance, capacitive reactance, or inductive reactance; or of repetitive momentary contact character. It is significant to note how easily overvoltages as high as five times normal can be developed on an ungrounded system and also how effectively these are eliminated by system grounding.

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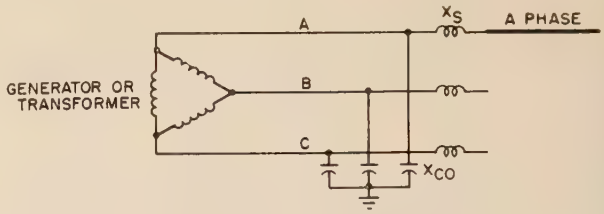
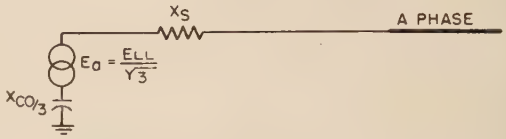
INSULATION BEHAVIOR

Is there need to worry about moderate overvoltages so long as they do not exceed the AIEE proof test values? Let's examine the behavior pattern of class A insulation as influenced by impressed voltage stress. The most authentic wide-range characteristic data are those published by V. M. Montsinger, presented before the AIEE in 1935, and embodied in the current issues of the Standard Handbook for Electrical Engineers. Extensive tests disclose that organic



3-PHASE ESSENTIAL ELEMENTS



EQUIVALENT CIRCUIT REFERRED TO A PHASE CONDUCTOR

UNGROUNDED 3-PHASE SYSTEM

Fig. 1

insulation exhibits the elements of progressive deterioration culminating in total failure. The time to failure is an inverse function of the impressed voltage stress. Reproduced in Fig. 3 is a representative curve showing the correlation between those two quantities. Of great significance to the problem at hand is the fact that a relatively small increase in applied voltage stress makes a tremendous change in the time to insulation breakdown. Note that over a voltage-stress range straddling the AIEE proof test value, an increase in voltage stress of 4.33 to 1 resulted in a decrease in the time to breakdown of 1,000,000 to 1. The shape of the curve is roughly hyperbolic. Thus, roughly, for each 30% increase in applied voltage stress, a ten-fold reduction in the time to breakdown can be expected. Here is powerful evidence of the extreme importance of avoiding unnecessary overvoltages if long insulation life is to be achieved.

ELECTRICAL SYSTEM GROUNDING

Effective grounding of the electrical distribution system can practically eliminate the overvoltage problem except for lightning and switching surges both in magnitude as well as duration. To be fully effective, a "stiff" grounding connection is required on low-voltage systems. Hence, for 600 v.

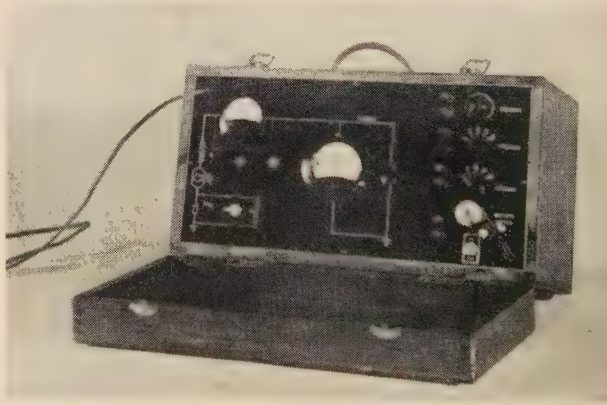


Fig. 2

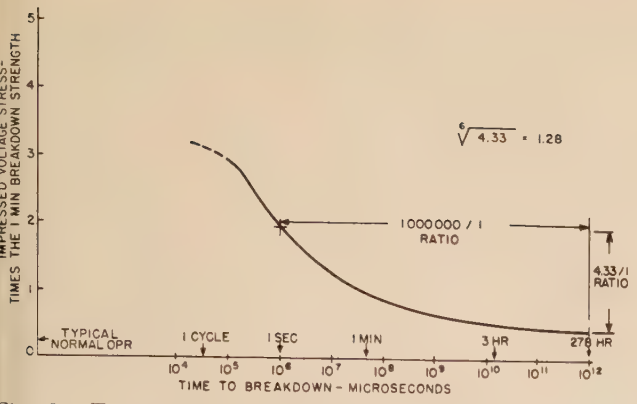


Fig. 3. Typical class A insulation breakdown strength based on treated pressboard in oil at 25 C. (V. M. Montsinger, Elec. Eng., Dec., 1935)

and less, solid neutral grounding is recommended. On higher voltage industrial distribution circuits, resistance grounding is the rule with the available ground fault current made about equal to the largest current transformer rating.

In addition to the elimination of overvoltages, system neutral grounding affords a number of additional benefits, namely

1. Faulty system elements are de-energized more quickly thus minimizing fault damage and fire hazard.
2. The tedious time-consuming job of locating a single ground fault is eliminated.
3. A great improvement in the quality of performance of rotating machine fault-protective relaying is accomplished.

INDICATED PERFORMANCE

Once the severe penalty in useful insulation life is recognized, the need for overvoltage control is fully evident. System grounding can tremendously reduce both magnitude and duration of possible overvoltages. The contended advantage of the ungrounded system—namely that a fault may be permitted to remain on the system until a convenient time of repair—takes on reversed meaning. The continued presence of a sputtering fault may well be the very thing which sets off a series of breakdowns which would not otherwise have occurred. Had the first fault been promptly switched off it might have been the last.

Note the snowballing elements in this situation. In the absence of disturbing influences, the voltage stress in grounded and ungrounded systems alike remains steady at an ideal low value. Only the appearance of a fault disturbance causes the two systems to exhibit different behavior. With the ungrounded system, the overvoltages created by the first fault might be responsible for creating the second fault. The overvoltages created by this second fault might then be responsible for the third, and so on. Once started, this chain reaction might continue until a considerable number of the weakest system elements had failed. This characteristic pattern involving a succession of failures during a relatively short time interval followed by a lengthy period of trouble-free operation is quite often experienced in actual system operation.

Perhaps the practice of allowing a faulty circuit to remain in operation on an ungrounded system loads to the occurrence of many equipment outages which might otherwise be avoided. Certainly if this be true, the entire case of ungrounded operation falls flat. The real proof of the pudding is in the eating. The best way to test the validity of the proposal that system neutral grounding will improve reliability and reduce outage rates is to examine the operating record of industrial plants originally operated ungrounded and later converted to grounded operation.

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A Qualitative Analysis of the Synthetic Fibers

MARJORIE LUNDEGARD and
ELIZABETH D. ROSEBERRY

Fifteen years ago the identification of the textile fibers was a relatively simple matter. A match and a microscope were all the equipment necessary for most purposes. If chemical reagents were needed, acetone or 5% sodium hydroxide were most commonly used.

Since then, with the development of the synthetic fibers, the problem of identification has grown more complex. A match, a microscope, and a simple reagent no longer give the answer. These fibers respond similarly when subjected to a flame. They are, for the most part, relatively inert chemically. They look very much alike in their longitudinal appearance when observed under the microscope, since they have no identifying characteristics, such as scales, nodes, etc. Only their cross-sectional appearances can be an aid in the identification of these fibers.

The purpose of this study was to develop an easy, accurate, and reproducible procedure to use for identifying the synthetic fibers. The synthetic fibers used were nylon, Dacron, Orlon, Acrilan, X-51, Dynel, Saran, and polyethylene. Of these, the Dynel and X-51 were staple fibers, and the others, filament fibers. Samples of each were obtained from the companies which produce them.

PROCEDURE

This study was divided into three parts. Part I was concerned with the solubility of the synthetic fibers in chemical reagents which were used in various concentrations and at different temperatures; part II dealt with the microscopy of the fibers; and part III dealt with miscellaneous tests which might be useful in the identification of the fibers.

In Part I, the various fibers were subjected to chemical reagents under standardized conditions in which the temperature was varied. The reactions were observed at room temperature, over a steam bath, and over a direct flame. First, a 30-ml. portion of the reagent was poured into an evaporating dish. Then, a 3-in. sample from each of the yarns was put in the evaporating dish so that about half of the sample was submerged in the solution. The samples were left in the reagent for 10 min. The results were recorded, noting whether the fiber was soluble, partially soluble, insoluble, or disintegrated.

In Part II, longitudinal and cross sections of the fibers were mounted on slides in Permount, and then examined under a Bausch and Lomb microscope with a magnification of 430×, using artificial light as the source of illumination.

In Part III, other methods of identification were used in an effort to obtain good positive tests for each fiber. The following tests were used:

(a) *Use of an identification dye:* Texchrome, produced by the Fisher Scientific Co, was used as the identification dye. A yarn from each sample was dyed with a drop of the dye, and after 2 min., was thoroughly rinsed. The color was noted.

(b) *Use of the flame test:* A yarn from each sample was advanced slowly toward the flame: The ignition of the sample, the odor, and the residue were observed.

(c) *The Lieberman-Storch test:* This test was used to detect the presence of the following groups by differences in color: vinyl acetate, vinyl acrylate, vinyl chloride, and vinylidene chloride. The sample was placed on a watch glass and covered with acetic anhydride. One drop of concentrated sulphuric acid was added to the liquid. The color change of the liquid and fiber was noted over a 30-min. period.

This work was done as a partial fulfillment of the requirement for the M.S. degree at Purdue University by Mrs. Lundegard under the direction of Professor Elizabeth D. Roseberry.

Table I. Reactions of the Synthetic Fibers to Various Organic Chemicals at Room Temperature[a]

Chemical compounds	*Nylon*	*Dacron*	*Orlon*	*Acrilan*	*X-51*	*Dynel*	*Saran*	*Polyethylene*
Methanol	I	I	I	I	I	I	I	I
Ethanol 95%	I	I	I	I	I	I	I	I
Cellosolve	I	I	I	I	I	I	I	I
1-4 dioxane	I	I	I	I	I	I	I	I
Methyl acetate	I	I	I	I	I	I	I	I
Amyl acetate	I	I	I	I	I	I	I	I
Acetone	I	I	I	I	I	S	I	I
Methyl ethyl ketone	I	I	I	I	I	I	I	I
Cyclohexanone	I	I	I	I	I	PS	PS	I
Glacial acetic acid	I	I	I	I	I	I	I	I
Maleic anhydride	I	I	I	I	I	I	I	I
Xylene	I	I	I	I	I	I	I	I
Benzene	I	I	I	I	I	I	I	I
Toluene	I	I	I	I	I	I	I	I
Monochlorobenzene	I	I	I	I	I	I	I	I
Carbon tetrachloride	I	I	I	I	I	I	I	I
Ethylene dichloride	I	I	I	I	I	I	I	I
Ethylene diamine	I	I	I	I	I	I	I	I
Dimethyl formamide	I	I	I	I	I	S	I	I
m-Cresol	S	I	I	I	I	I	I	I
Phenol 80%	S	I	I	I	I	I	I	I
p-Nitro phenol 70%	I	I	I	I	I	I	I	I

[a] Time of treatment: 10 min.
I = insoluble. PS = partially soluble. S = soluble.

Table II. Reactions of the Synthetic Fibers to Various Organic Chemicals When Heated on a Steam Bath[a]

Chemical compounds	*Nylon*	*Dacron*	*Orlon*	*Acrilan*	*X-51*	*Dynel*	*Saran*	*Polyethylene*
Methanol	I	I	I	I	I	I	I	I
Ethanol 95%	I	I	I	I	I	I	I	I
Cellosolve	I	I	I	I	I	I	I	I
1-4 Dioxane	I	I	I	I	I	PS	S	I
Methyl acetate	I	I	I	I	I	I	I	I
Amyl acetate	I	I	I	I	I	I	I	I
Acetone	I	I	I	I	I	S	I	I
Methyl ethyl ketone	I	I	I	I	I	S	I	I
Cyclohexanone	I	I	I	I	I	S	S	I
Glacial acetic acid	S	I	I	I	I	I	I	I
Maleic anhydride	S	I	I	I	I	I	I	I
Xylene	I	I	I	I	I	I	I	S
Benzene	I	I	I	I	I	I	I	S
Toluene	I	I	I	I	I	I	I	S
Monochlorobenzene	I	I	I	I	I	I	S	S
Carbon tetrachloride	I	I	I	I	I	I	I	S
Ethylene dichloride	I	I	I	I	I	PS	PS	I
Ethylene diamine	I	I	I	I	I	I	Turns brown	I
Dimethyl formamide	I	I	S	S	S	S	S	I
m-Cresol	S	S	I	I	I	PS	I	I
Phenol 80%	S	S	I	I	PS	S	I	I
p-Nitro phenol 70%	S	I	I	PS	S	PS	I	I

[a] Time of treatment: 10 min.
I = insoluble. PS = partially soluble. S = soluble.

(d) *A test to detect chlorine:* A small sample of the yarn was put in a clean Pyrex test tube which was held over a flame. The fumes from the yarn were caught in another test tube. These fumes were dissolved in 5 ml. of distilled water. A few drops of silver nitrate were added to this solution. If chlorine was present, a white precipitate of silver chloride was formed which could be dissolved in ammonia.

In dealing with the reactivity of the fibers in the chemical compounds, the following general aspects of solubility were kept in mind: (1) that similar or like chemical and structural features favor solubility; (2) that similar internal pressures favor solubility; (3) that similar polarity between solute and solvent favor solubility (*4*).

The reactions of the synthetic fibers used in this study to various organic chemical compounds at room temperature are shown in Table I. Table II shows the results using the same chemicals over a steam bath. The reactions of these fibers to various inorganic compounds at room temperature and also on a steam bath are shown in Tables III and IV. Table V shows the results obtained with the latter compounds when a direct flame was used as the source of heat.

FINDINGS

Nylon

Nylon, a polyamide, has many amide linkages which are easily destroyed by concentrated mineral acids. It was found to be affected by the phenolic compounds, phenol and *m*-cresol, at room temperature, and the organic acid, glacial acetic, if heated. Nylon was found to be soluble in 50% solutions of zinc chloride and calcium chloride when heated on the steam bath for 10 min., and also a 50% solution of lithium bromide when heated over the direct flame. Nylon however, was not affected by the halogenated hydrocarbons, alcohols, ketones, ethers, esters, and alkalies.

Dacron

Usually esters are readily hydrolyzed, but this is not true of Dacron, which is a polyester. At room temperature, it is not visibly affected by weak or strong alkalies. However, in our work, it was found that Dacron was destroyed in boiling strong alkalies, and was attacked by boiling weak alkalies. It was found that 95% sulphuric acid would disintegrate Dacron, but that 70% sulphuric acid would give no visible evidence of disintegrating it. It is also attacked by 37% hydrochloric acid. It has been claimed that boiling ethylene diamine would dissolve it (*2*), but the Dacron used in this study did not dissolve when subjected to this compound. At room temperature, Dacron was found to be insoluble in 80% phenol, but when this solution was heated, the fiber was dissolved. Meta-cresol dissolves Dacron only when heated.

The Acrylics

Since the "acrylic" fibers, Orlon, Acrilan, and X-51, resemble each other chemically, they will be discussed to-

Table III. Reactions of the Synthetic Fibers to Various Inorganic Compounds at Room Temperature[a]

Inorganic compounds	*Nylon*	*Dacron*	*Orlon*	*Acrilan*	*X-51*	*Dynel*	*Saran*	*Polyethylene*
95% sulphuric acid	D	D	D	D	D	A	I	I
70% sulphuric acid	D	I	I	I	I	I	I	I
60% sulphuric acid	D	I	I	I	I	I	I	I
37% hydrochloric acid	D	I	I	I	I	I	I	I
20% hydrochloric acid	D	I	I	I	I	I	I	I
60% nitric acid	D	A	D	D	D	A	I	I
50% potassium hydroxide	I	I	I	I	Turns orange	I	I	I
40% sodium hydroxide	I	I	I	I	Turns orange	I	I	I
5% sodium hydroxide	I	I	I	I	Turns orange	I	I	I
29% ammonium hydroxide	I	I	I	I	I	I	I	I
50% zinc chloride	I	I	I	I	I	I	I	I
50% calcium chloride	I	I	I	I	I	I	I	I
50% lithium bromide	I	I	I	I	I	I	I	I
70% ammonium thiocyanate	I	I	I	I	I	I	I	I
70% potassium thiocyanate	I	I	I	I	S	I	I	I
calcium thiocyanate	I	I	S	S	S	I	I	I

[a] Time of treatment: 10 min.
I = insoluble. S = soluble. A = partially disintegrates. PS = partially soluble. D = disintegrates.

Table IV. Reactions of the Synthetic Fibers to Various Inorganic Compounds when Heated on a Steam Bath[a]

Inorganic compounds	*Nylon*	*Dacron*	*Orlon*	*Acrilan*	*X-51*	*Dynel*	*Saran*	*Polyethylene*
5% sulphuric acid	D	D	D	D	D	A	I	I
0% sulphuric acid	D	I	I	D (slowly)	D	I	I	I
0% sulphuric acid	D	I	I	I	D (slowly)	I	I	I
7% hydrochloric acid	D	I	I	I	I	I	I	I
0% hydrochloric acid	D	I	I	I	I	I	I	I
0% nitric acid	D	A	D	D	D	A	I	I
0% potassium hydroxide	I	I	I	I	Turns orange	I	I	I
0% sodium hydroxide	I	I	I	I	Turns orange	I	I	I
5% sodium hydroxide	I	I	I	I	Turns orange	I	I	I
9% ammonium hydroxide	I	I	I	I	I	I	I	I
0% zinc chloride	S	I	I	I	S	I	I	I
0% calcium chloride	S	I	I	I	I	I	I	I
0% lithium bromide	I	I	I	I	I	I	I	I
0% ammonium thiocyanate	I	I	S	S	S	PS	I	I
0% potassium thiocyanate	I	I	S	PS	S	I	I	I
calcium thiocyanate	I	I	S	S	S	I	I	I

[a] Time of treatment: 10 min.
I = insoluble. S = soluble. A = partially disintegrates. PS = partially soluble. D = disintegrates.

ether. Acrilan and X-51 are copolymers having different inyl derivatives as their minor components, while Orlon is 100% acrylonitrile fiber. Fibers containing as much as 5% of acrylonitrile will react similarly, no matter what their inor constituents. Orlon, Acrilan and X-51 are not affected y such organic solvents as ketones, alcohols, esters, ethers, romatic hydrocarbons, and halogenated hydrocarbons. revious work showed that Orlon was soluble in lithium bro- ide, dimethyl formamide, and *p*-nitro phenol (*1*). In our tudy, however, it was found that Orlon was not soluble in ny of these three compounds at room temperature, but was oluble in dimethyl formamide when heated on a steam bath. ammonium thiocyanate and 70% potassium thiocyanate if heated on the steam bath. All were destroyed in cold 95% sulphuric acid, but unaffected in cold 60 or 70% sulphuric acid. X-51 was the only one which disintegrated in the 60% solution when it was heated on the steam bath, while both X-51 and Acrilan were destroyed in the 70% solution thus heated. Concentrated hydrochloric acid did not affect the fibers. Only X-51 was found to turn orange in color when subjected to an alkali at room temperature. However. Orlon and Acrilan turned orange in color when they were heated in an alkali over the direct flame. Since Acrilan and X-51 are known to be copolymers, various reagents were used

Table V. Reactions of the Synthetic Fibers to Various Chemical Compounds when Heated Over the Direct Flame[a]

Reagents	*Nylon*	*Dacron*	*Orlon*	*Acrilan*	*X-51*	*Dynel*	*Saran*	*Polyethylene*
0% sulphuric acid	D	I	D	D	D	I	I	I
0% sulphuric acid	D	I	D	D	D	I	I	I
0% potassium hydroxide	I	D	Turns orange	Turns orange	Turns orange	I	I	I
0% sodium hydroxide	I	D	Turns orange	Turns orange	Turns orange	I	I	I
5% sodium hydroxide	I	I	Turns orange	Turns orange	Turns orange	I	I	I
9% ammonium hydroxide	I	I	I	I	I	I	I	I
0% lithium bromide	S	I	S	S	S	S	A	I (shrinks)

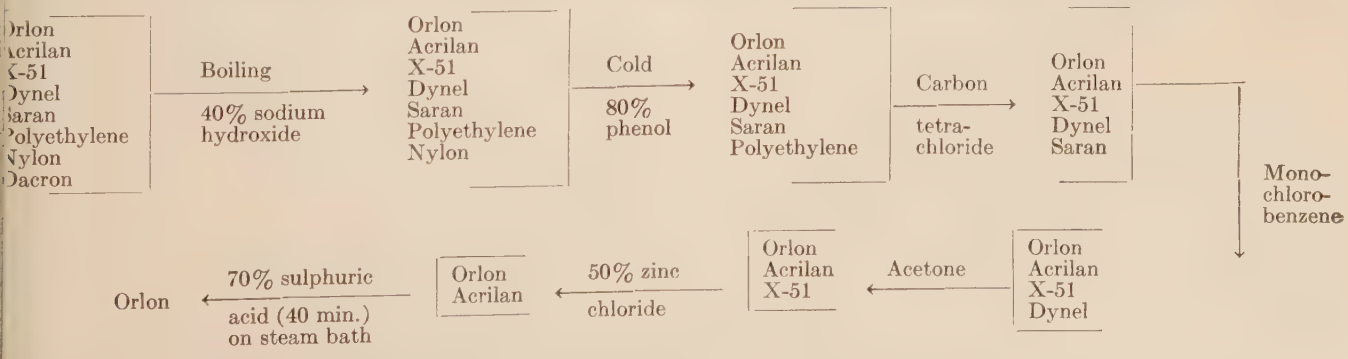
[a] Time of treatment: 10 min. I = insoluble. S = soluble. A = partially disintegrates. PS = partially soluble. D = disintegrates

crilan and X-51 were also soluble in this reagent when eated on a steam bath. Only X-51 of the acrylic fibers was ound to be soluble in 70% *p*-nitro phenol when heated on a team bath, while Acrilan was found to be partially soluble, nd Orlon insoluble. All three were found to be soluble in a 0% solution of lithium bromide when it was heated over a irect flame. It was found that these three fibers were solu- le in calcium thiocyanate at room temperature, and in 70% which were specific for the constituents that are thought to be the minor components in the fibers. However, because there is such a small percentage of these constituents present, the chemical compounds chosen had no effect.

Dynel

Dynel, a copolymer which has as its minor constituent acrylonitrile and as its major constituent vinyl chloride,

Table VI. Flow Sheet Showing Chemical Means for Separation and Identification of the Synthetic Fibers[a]



[a] Time of treatment is 10 min. heated on a steam bath unless stated otherwise.

Table VII. Summary of Tests for the Identification of Synthetic Fibers

	Flame test		Chemical tests[a]								
	Residue	*Miscellaneous properties*	*Calcium thiocyanate*	*Acetone*	*Carbon tetrachloride*	*Cyclohexanone*	*Glacial acetic acid*	*80% phenol*	*50% zinc chloride*	*70% sulphuric acid*	*Identification stain (Texchrome)*
Nylon	White noncrushable bead	Does not support flame, amide odor	I	I	I	I	S	S	S	D	Lime yellow
Dacron	White noncrushable bead	Does not support flame, aromatic odor	I	I	I	I	I	S	I	I	Lavender
Orlon	Black noncrushable bead	Supports flame, acrid odor	S	I	I	I	I	I	I	I	Pale blue
Acrilan	Black noncrushable bead	Supports flame, acrid odor	S	I	I	I	I	I	I	D (slowly)	Pale blue
X-51	Black noncrushable bead	Supports flame, acrid odor	S	I	I	I	I	PS	S	D	Dark gray, blue
Dynel	Black moderately crushable bead	Does not support flame, acrid odor	I	S	I	S	I	S	I	I	Gray-green, blue
Saran	Black moderately crushable bead	Does not support flame, chlorine odor	I	I	I	S	I	I	I	I	No color
Polyethylene	Waxy bead	Supports flame, hot paraffin odor	I	I	S	I	I	I	I	I	No color

[a] Heat 10 min. on steam bath.
I = insoluble. S = soluble. PS = partially soluble. D = disintegrates.

reacted differently in some chemicals in which Orlon, Acrilan, and X-51 were soluble. It was not soluble in calcium, potassium, or ammonium thiocyanate. It was affected slightly by 95% sulphuric acid and concentrated nitric acid, but found to be inert in concentrated hydrochloric acid. Dilute or concentrated alkalies, inorganic salts, organic acids,

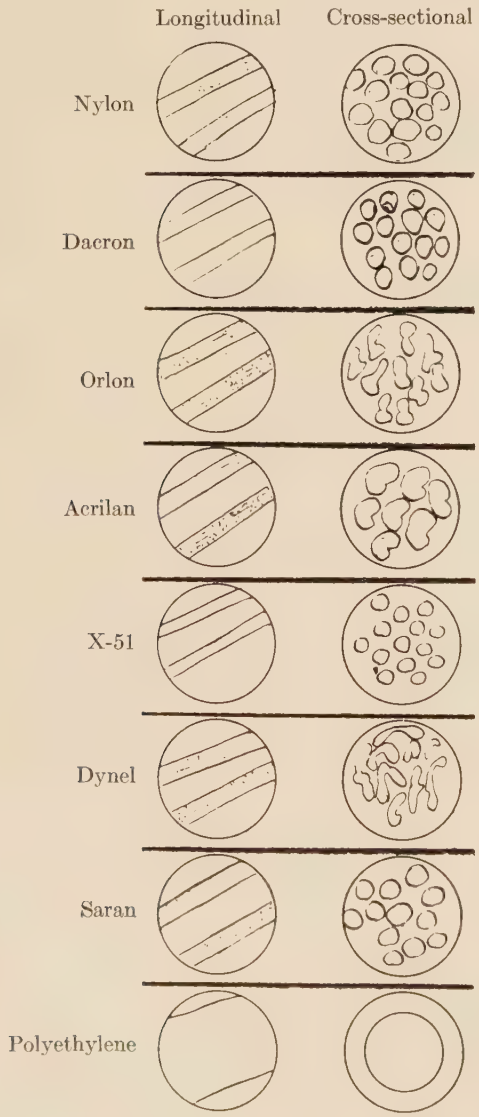


Fig. 1. Microscopic test

and aromatic hydrocarbons had no effect on Dynel. It was soluble in ketones and pyridine.

Saran

Saran, a copolymer of vinyl chloride and vinylidene chloride, was not affected by the alcohols, mineral acids at all concentrations, alkalies, organic acids, and inorganic salts. In an article written by Kenneth Rose (*3*), it was claimed that Saran was soluble in ammonium hydroxide. However, in our experiments it showed no visible effects when subjected to this compound, either hot or cold. Temperature was an important factor in the effects of many chemicals used. Pyridine, cyclohexanone, 1-4 dioxane, monochlorobenzene, and dimethyl formamide had no visible effect on Saran at room temperature, but when these chemicals were heated on a steam bath, Saran was dissolved.

Polyethylene

Polyethylene, a polymer of ethylene, is inert in most organic and inorganic chemicals. Halogenated hydrocarbons and the aromatic hydrocarbons, when heated on a steam bath 10 min., were the only chemicals among those used in this study which dissolved this fiber.

DISCUSSION

As a means of using the foregoing information on the solubilities of the synthetic fibers, Table VI is presented. It is a simplified flow sheet showing how the synthetic fibers can be separated and identified by means of specific reagents which will dissolve only one of the fibers. Concentrations and temperatures are given.

With the aid of the microscope, the identity of some of the synthetic fibers can be verified. Although all the synthetic fibers have somewhat similar longitudinal appearances, the cross-sectional views are more characteristic of each fiber. The cross-sectional views of Dacron, nylon, Saran, polyethylene, and X-51 are round. It is possible that Orlon and Acrilan could be confused as Orlon has a dog-bone shape and Acrilan has a shape like a kidney bean. Dynel has the distinctive cross-sectional appearance of a twisted ribbon. (See Fig. 1.)

Ofttimes identification stains help in the determination of a fiber, but obviously white fibers are necessary for this type of test. In this study, Texchrome was used as the colorant for the fibers. Nylon was the only fiber which gave a truly distinctive color. The color produced on X-51 was a darker shade of blue than the color produced on the other acrylic fibers. Saran and polyethylene did not show any color with this stain. Although the colors obtained were not too specific, this staining test might be used as an additional con-

irmatory test along with the solubility and microscopic tests.

Since Acrilan is thought to contain vinyl acetate as its minor component, and X-51 is said to contain methyl methacrylate, the Lieberman-Storch test was used to detect the presence of these groups. However, no color change was observed on the fibers.

The results obtained from the flame test showed that the identity of the fibers could not be ascertained with this test. The odors, although difficult to describe, are characteristic for many of the fibers. Nylon has an amide odor; Dacron, an aromatic odor; Orlon, Acrilan, X-51, and dynel, an acrid odor; Saran, a chlorine odor; and polyethylene, a paraffin odor. Dacron, nylon, Saran, and Dynel do not support a flame, while Orlon, Acrilan, X-51, and polyethylene will support a flame. If Saran and Dynel are ignited, they are self-extinguishing. Nylon and Dacron form white noncrushable residues; polyethylene, a waxy residue; the acrylics, a black noncrushable residue; and Saran and Dynel, a black moderately crushable residue.

The fibers containing chlorine can be identified as such by use of a specific test to detect the presence of chlorine. This would be a good preliminary test to use. If the chlorine test is positive, then the fiber is either Dynel or Saran.

All information necessary for the identification of the synthetic fibers in this study is briefly summarized in Table VII and Fig. 1. When possible, the chemicals chosen should be specific for each fiber. Table VII incorporates the solubility test, an identification stain test, and the flame test. Figure 1 incorporates the microscopic test.

LITERATURE CITED

1. Anon., "Synthetic Fibers," *Chemical Engineering* 125 (Aug., 1951).
2. General Technical Committee C, "Identification of Textile Materials," *Textile Inst.* 42: S25 (1951).
3. Rose, Kenneth, *Materials and Methods* 34: 76 (Aug., 1951).
4. Schmidt, Alois X., and Marlies, Charles A., "Principles of High Polymer Theory and Practice," McGraw-Hill Book Co., Inc., New York, 1948.

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LETTERS TO THE EDITOR

Cracked Scorelines

To the Editor, *Tappi:*

This facility is investigating the performance of fiberboard containers for packaging canned foods. It has come to our attention that the heavy W5 and V3C containers frequently have cracked scorelines in both the vertical and horizontal directions.

We would appreciate information on any industrial methods for laboratory evaluation of fiberboard scorelines that may be available. Any performance data or strength standards that could be applied would be helpful.

I. A. Trygg, *Lieutenant SC USN*
Supply Engineering Officer
U. S. Naval Supply Research and Development Facility
Bayonne, N. J.

To the Editor, *Tappi:*

The only test we know of which might be adaptable to evaluation of scorelines, and which is sometimes referred to as a scoreline test is conducted as follows:

1. Cut strips $1^1/_8$ in. wide and 10 in. long and with the score to be tested 3 in. from one end.
2. Tightly clamp the test specimen in the Mullen tester with inner surface down and with the scoreline at center of the clamp.
3. Apply the Mullen test in the usual manner, allowing the rubber diaphragm to tear the specimen in the scored area.
4. Remove the specimen and repeat the test in the unscored area.

The differences in readings of tests in the scored and unscored areas comparatively measure:

(a) Losses in strength due to scoring.
(b) Losses of strength due to cracking (if the specimen has been folded before testing).
(c) Relative scoreline strengths of containers made of various materials.

Any test such as this, of course, is influenced by the moisture conditions, and should be made under standard conditions. In actual use, however, boxes are subjected to various conditions of atmospheric moisture variations, tending to crack more when folded when dry than when moist. Also, less cracking occurs when small samples are folded than when large panels are folded. This is probably because in small samples there is more freeness to allow "drawing." In large samples, "drawing" is more restrained.

A straight tensile test on the scored and unscored areas would probably give a comparable measure of strength loss due to scoring and folding.

Except for these methods, we can think of no other means of measuring strength losses due to cracking of scores.

J. J. Koenig
Gaylord Container Corp.
St. Louis, Mo.

Cellulose Constants

To the Editor, *Tappi:*

For our laboratory work I am looking for various physical and chemical constants of cellulose and trying to get the most modern measurements.

Primarily I am thinking of the dielectric constant, insulation resistance, refraction index, heat of combustion, heat of crystallization, and density.

I would be very obliged to you if you could give me their values and the respective literature references.

Heinz Temming
Glückstadt, Hamburg, Germany

To the Editor, *Tappi:*

I have assembled available data on those constants of cellulose requested by Dr. Temming. Some of them are readily available and reliable; others are more difficult to locate and more dubious. I am therefore giving not only the numerical constants, but some comments as well.

(*1*) *Dielectric Constant.* The dielectric constant of cellulose varies with density, temperature, moisture content, and crystallinity. It is also anisotropic. Recent measurements by Verseput [*Tappi* 34: 522 (1951)] found values of 2.2 to 2.3 on sheeted native celluloses at 30°C. and 1000 cycles, corrected to a density of 0.7. The value usually cited for the solid cellulose alone is that of DeLuca, Campbell, and Maass 6.1 [*Can. J. Res.* 16B: 273: (1938)].

(*2*) *Insulation Resistance.* This has been the subject of a great deal of study by the American Society for Testing Materials and the publications of Committee D-9 contain a great deal of value. Particularly useful are the annual reviews *Digest of Literature on Dielectrics* begun by this committee 18 years ago and now published by the National Research Council. The Division of Engineering and Industrial Research of this latter group holds an annual conference on electrical insulation, the proceedings of which are also published. Finally, Hearle published in 1952 an excellent review paper in the *Journal of the Textile Institute* 43: 194, "Electrical Resistance of Textile Materials."

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The value of electrical resistance for pure cellulose is not easy to come by. It is highly dependent upon moisture content and upon electrolyte content. Since even the purest cellulose available appears to have some ion-exchange capacity for cations, the resistivity will depend upon which ions are present. H. F. Church [*J.S.C.I.* 661: 221 (1947)] tested a high quality electrical tissue paper, free of mechanically held salts. The resistivity originally 11×10^{13} ohm-cm. rose to 21×10^{13} after washing in distilled water, went to 4.4×10^{13} after treatment with HCl, and up to 34×10^{13} after treatment with calcium acetate. Which, if any, of these values can we take for the resistivity of cellulose? I do not pretend to know. These were measured at 100° after a standardized (but not described) drying procedure and, of course, tissue paper is not pure cellulose. Walker, working with cotton washed free of electrolytes and with standard cotton cellulose could not get values below 0.04% moisture content, but at this point the insulation resistance was rising rapidly and, if his equation holds, should approach infinity. If his conditioning was from the dry side (there is a hysteresis loop) a $^1/_2$-in. length of 30/2 cotton thread at 25°C. and 8% R.H. had a resistance of almost 10^{10} megohms.

Obviously, then, the insulation resistance of cellulose will have to be measured under specifically stated conditions. I recommend that having established whichever conditions you choose you make use of the data for water-boiled cotton in Walker's papers [*J. Text. Inst.* 24T145 (1933) and *J. Applied Physics* 8: 261 (1937)].

(*3*) *Refractive Index.* A good discussion of the refractive index of cellulose may be found in Hermans' "Physics & Chemistry of Cellulose Fibers," pages 214–237. Cellulose is anisotropic. In addition to this, the refractive index will depend on the nature of orientation (of the molecules or of the crystallites) and on the density. Hermans has calculated for an ideal fiber (perfect orientation parallel to the fiber axis and the density of crystalline cellulose) that the refractive index would be 1.618 parallel to the fiber axis and 1.543 perpendicular to it. Ramie which comes most nearly to approximating such an ideal fiber has refractive indices of 1.601 and 1.530, respectively.

(*4*) *Heat of Combustion.* Jessup and Proser [*J. Res. Natl. Bur. Standards* 44: 387 (1950)] have determined the heat of combustion of linters to be 4165 cal. per gram and wood cellulose to be 4172.8 cal. per gram.

(*5*) *Heat of Crystallization.* Calvet and Hermans [*J. Polymer Sci.* 6: 33 (1951)] have calculated the heat of crystallization of cellulose as 4100 ± 200 cal. per mole. Their assumption that the heat of crystallization will be the same for the two crystalline forms, Cellulose I and Cellulose II looks unlikely to the writer, however [Ward and Reeves, *J. Polymer Sci.* 6: 778 (1951)] and the value seems to require confirmation.

(*6*) *Density.* The density of cellulose must be defined before a value can be assigned. If it is determined by a buoyancy method it will depend on the buoyant medium. Purified cotton cellulose in heptane was found to be 1.540 by Biltz [*Z. Physik Chem.* 151A: 13 (1930)]. Davidson found it to range 1.548–1.550 in toluene, 1.558–1.567 in helium, and 1.6038–1.6095 in water. The density of crystalline cellulose is given by Hermans in his book, "Physics and Chemistry of Cellulose Fibers," as 1.592. Pages 197–213 of this book are recommended for a discussion of the difficulties involved in the concept of cellulose density.

KYLE WARD, JR.
The Institute of Paper Chemistry
Appleton, Wis.

To the Editor, *Tappi:*

We do not have data for the heat of crystallization of any cellulosic material.

We have dielectric constant values only for wood. Dry wood values vary directly with specific gravity. From 0.3 to 0.8 specific gravity the values at 2 megacycles per second vary from 1.6 to 2.7. The values increase greatly with an increase in moisture content.

Direct current electrical resistance values decrease rapidly with an increase in moisture content. Hearle, *J. Text. Inst.* 43, No. 4: 194 (1952), gives values for cellulose of different sources. Oven-dry wood has values of 3×10^{17} to 3×10^{18} ohm-cm. At the fiber saturation point, about 30% moisture content, the values drop to about 1×10^3 ohm-cm.

The axial index of refraction of ramie cellulose is 1.595 and the transverse, 1.334. Double refraction is 0.061. Celluloses with less preferred orientation give lower axial values and higher transverse values; for example, cotton gives 1.578 and 1.532.

The heat of combustion of wood varies only slightly with species, 8400 to 8800 B.t.u. per pound. The value for lignin is 10,000 B.t.u. per pound. Cellulose values should hence be about 8100 B.t.u. per pound.

The measured specific gravity of cotton cellulose varies with the displacing medium, 1.602 in water, 1.570 in benzene, and 1.585 in helium. The x-ray value is 1.590.

ALFRED J. STAMM, *Subject Matter Specialist*
Forest Products Laboratory, Madison Wis.

Eighth Alkaline Pulping Conference

Dinkler-Tutwiler Hotel
Birmingham, Alabama

October 6–8, 1954

RECENT BOOKS

Chemical Engineering in Practice. Edited by James I. Harper, Sun Oil Co. Reinhold Publishing Corp., New York, 1954. Cloth, 5¼ × 7¾, 140 pages. $3.00.

A compilation of papers presented in a symposium entitled "Chemical Engineering in the Process Industries," sponsored by the Philadelphia-Wilmington Section of the American Institute of Chemical Engineers. The chapters include "Process Research," by G. Alex Mills, Houdry Process Co.; "Process Development," by J. J. Hur, Atlantic Refining Co.; "Economic Analysis," by E. M. Ott, Pennsylvania Salt Mfg. Co.; "Project Engineering," by W. F. Cook, du Pont; "Construction Engineering," by G. L. Eaton, United Engineers & Constructors; "Operational Engineering," by W. C. Huffman, Sun Oil Co.; and "Market Research Engineering," by R. E. Chaddock, Hercules Powder Co.

Rapid Detection of Cations. By Gaston Charlot, Denise Bezier, and Rolland Gauguin, École de Physique et Chime de Paris; translated by Ralph E. Oesper, University of Cincinnati. Chemical Publishing Co., New York, 1954. 5¼ × 8, 92 pages. $3.00.

This book is an English translation of a successful French text that should be useful to analytical chemists. The goal of the information is to show how to detect each metal in the presence of 100 to 1000 times larger quantities of any other metal. The identifying tests are specific and selective. Selective reactions are included to determine the absence of an entire group of elements. Included are tests for strong reducing agents.

Industrial Fermentations. Vol. I. Edited by Leland A. Underkofler, Iowa State College, and Richard J. Hickey, Commercial Solvents Corp. Chemical Publishing Co., New York, 1954. 5½ × 8½, 565 pages. $12.

Volume I of "Industrial Fermentations" was prepared by nineteen collaborators, all experts in their respective fields. Included are chapters on alcoholic fermentation of grain, molasses, sulphite waste liquor (by J. L. McCarthy, University of Washington), wood waste (by J. F. Saeman and A. A. Anderson, Forest Products Laboratory), commercial food and feed yeast manufacture (by A. J. Wiley, Sulphite Pulp Manufacturers' Research League), lactic acid, gluconic acid, fumaric acid, itaconic acid, and acetic acid. The chapters on yeast, spent sulphite liquor, and wood waste fermentation are excellent and should be of interest to workers in the sulphite pulping industry.

Note: Books reviewed in this column may be obtained from the Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

Ninth Engineering Conference

Benjamin Franklin Hotel
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E276-54. Pulp Mill Executive. Science graduate, over 20 years' extensive technical and operating experience in sulphite pulping and bleaching for paper and dissolving grades; also research, cost, and quality control, some sulphate. Desire change to executive position with progressive concern.

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P381-54. Young Chemist or Chemical Engineer with or without previous paper mill experience to assist chief chemist in the main laboratory of a large integrated fine paper mill located in northern Wisconsin. Please give a complete résumé in the first letter.

P383-54. Salesman with chemical training and experience in paper manufacture and pigmented coatings—to sell adhesives. This is an excellent opportunity with a progressive company. Location Middle West.

P384-54. Physicist or experienced testing engineer for physical research study of paper, plastic films, foils, etc. An interesting research program requiring original thinking awaits candidate. Best modern equipment available in pleasant working conditions. Prefer M.S. but will consider B.S. Send résumé of training and experience and indicate salary requirements.

P385-54. Major board producer requires a technically trained man experienced (over two years) in either paper or board machine coating for addition to technical staff. New England base location but job will require traveling. Salary liberal but dependent on experience.

P386-54. Ohio board mill requires Chemical Engineer or Graduate Chemist; under 35. Paper training or experience valuable, not necessary. Salary commensurate with qualifications. Submit complete information first letter.

P387-54. Master's degree in Chemistry or Chemical Engineering. Two years' experience on paper coatings, resins, light-sensitive material, and water-soluble gums. Knowledge of offset lithography desirable.

P388-54. Design Engineer. General Information: The Bowaters Southern Paper Corp. has established its principal office on the site where the company's paper mill is being completed. This location is on U. S. Highway 11, 43 miles northeast of Chattanooga at the junction of the Hiwassee River and U. S. Highway 11. This site, in the vicinity of Charleston-Calhoun, is approximately 13 miles northeast of Cleveland and 15 miles southwest of Athens. The mill together with its facilities for procurement of pulpwood, will represent a capital investment in excess of $50,000,000.00. The company will manufacture newsprint and sulphate pulp. It is a wholly owned subsidiary of the Bowater Paper Corp., Ltd., London, England. The parent company, established in 1882, now operates more than 38 subsidiary companies for the manufacture and sale of paper and paper products. Included in the subsidiary companies is Bowater's Newfoundland Pulp and Paper Mills Ltd., at Corner Brook, Newfoundland, which is one of the largest integrated newsprint mills in Canada. Duties: Drafting, design, layouts, reports, cost estimating, and general engineering field work as required in the pulp and paper industry. Education and Experience: Degree from recognized college in Mechanical or Civil Engineering. Minimum of five years' experience. Personal Qualifications: Age to 36. Candidates should have a good facility for working with people and for working under only general supervision. Salary: Beginning salary will be determined upon individual's qualifications. Procedure for periodic merit review of salaries has been established. Liberal benefit program established including insurances, vacations, retirement plan, etc. Procedure for Handling Applications: (1) Prepare as thoroughly and completely as possible the Bowaters Southern Paper Corp.'s Application for Employment. This form may be obtained directly from the company. (2) The snapshot requested is optional. (3) If necessary, a detailed summary of education and work experience may be attached to the completed application form. (4) The Application and the supplementary material should be mailed to: Industrial Relations Dept., Bowaters Southern Paper Corp., Calhoun, Tenn. (*Note:* It is requested that applicants not make a trip to the company's office unless a specific appointment has been made in advance. All applications will be acknowledged and treated as confidential.)

P389-54. Paper Mill Superintendent for new extra wide cylinder board machine located in the South. Furnish to consist of bleached kraft and bleached hardwood pulps. Experienced in the manufacture of food board specialties and capable of understanding and developing many innovations incorporated in the new paper machine. Submit age, education, experience, present position, and past positions.

Miscellaneous

A7-54. For sale. Leeds & Northrup SO_2 analyzer, recorder, and controller. New and unused. Write to C. S. White, The Racquette River Paper Co., Potsdam, N. Y.

A8-54. Active Agent wanted. Well-established manufacturer of chemicals requires agent visiting regularly the paper industry in Ohio Valley, New England States, and Far West.

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PAPER-PLASTICS CONFERENCE

New York State College of Forestry, Syracuse, N. Y., Sept. 15, 1953

Chairman R. T. Nazzaro (Westfield River Paper Co.): Gentleman of TAPPI, it is my pleasure to introduce to you the Acting Dean of the College of Forestry, Dean Belyea.

H. C. Belyea: In the absence of Dean Illick, who is attending the Summer meeting of the Society of American Foresters in Colorado Springs, and in the absence of your fellow TAPPI member, Associate Dean, Edwin Jahn, who is in Rome attending the sessions of the International Forest Research Congress, it is my pleasure to extend a word of welcome to you for your 1953 Paper-Plastics conference.

It is not the first time that you have been here and we are very glad to welcome you back—not as new acquaintances, but as old friends. I want to assure you that as old friends the door is always wide open to you and our welcome mat is spread far and wide and handsome.

My word of welcome may be summed up in perhaps three short sentences. We hope that you will have a good time. We trust that you will enjoy the program which has been prepared for you to the full. We sincerely trust that you will want to come again.

Chairman: On behalf of TAPPI I want to also add my word of welcome. On behalf of the TAPPI Plastics Committee, we sincerely hope this meeting will contribute in some small way to the progress of the field of plastics.

I think it is only fitting that the meeting should come here to the College of Forestry where a great deal of pioneering work has been done in paper technology.

I now wish to introduce our outstanding friend, Professor Herman Mark, Polytechnic Institute of Brooklyn, who will be chairman of the day's session.

New Resin Developments

Chairman: You have seen that we have six formal presentations and then there is time for a discussion. I talked it all over with the individual speakers and found out how much time they would like to have and it seems that the best way of running this meeting might be that we consider having the first three papers in the morning.

I would suggest we have some discussion after each paper—those questions which are rather closely connected with the content of the paper—and save for the general discussion the more general remarks or questions of a more general character for a panel session at the end. I think this is the best way to give our speaker a good chance to tell us everything he wants and give us a chance at him too for those things we would particularly like to know.

Before I call on our first speaker, I would like to express the thanks of TAPPI and particularly the program committee of the plastics group, to our speakers for the very kind and cooperative way in which they have consented to give their talks here and to stand up in the crossfire for questions.

Our first speaker is Mr. Rochow. There are two Rochows, Eugene and Ted, and he is Ted. I have known him for years. He has an outstanding position at the Stamford Laboratory of the American Cyanamid Co. His topic is "Resinography." He has developed a systematic use of this and today he is going to tell us about the results which he has accumulated over the course of many years and which, you will see, are very pertinent to the general topic of this meeting. Mr. Rochow!

Resinography

T. G. ROCHOW

Resinography comes from the same stock as metallography and mineralography and follows the old and new adage that "looking and seeing are believing—and understanding." The purpose of resinography is to see the actual particles that are effective in modern, mass-fabrication by processes of plastic deformation, such as molding, pressing, extruding, milling, and drilling. As far as the writer knows, however, resinography does not make much of anything (including money), nor does it use materials in commercial quantities, but it does connect these two industrial essentials, very often closing the gap that otherwise keeps them apart. This connection can be illustrated in the form of a triangle. By looking and seeing what goes on among the constituent particles, during the making and fabrication of materials such as resins, pulp, and paper, and during the wear and tear of using their products, we learn to understand the whole relationship. Eventually, we can deduce any one part from data about the other two. For example, if we know how a material is made and how it behaves during use, we perceive a mental image of its appearance, based on previous experience. Or, if we have learned the variations in morphology (structure or texture) which follow variations in manufacture we can predict the variations in performance. In the third case, and this is especially interesting if we are dealing with a competitor's product, if we know how a material performs and can see its effective particles, we can indicate how it was made.

In resinography (as in metallography and mineralography) we deal with constituent grains of particles *in situ*. For example, we can examine the coating on commercially coated paper, as proved in test or use, to be good *or* bad. One way would be to examine it in cross section. In a microtomed section of coated paper, we can see by transmitted light at about 250×, the variation in thickness of the coating and the extent of its penetration of its effective particles into the paper. We could examine either the coating or the paper at further detail, depending on the analytical or synthetical problem at hand. If we get sufficiently close to the inhabitants of the kingdom of clays, we see that they are all crystalline and of distinctly different habits. Indeed, the clays can be described and recognized by their crystalline habit alone, and as Project 49, the American Petroleum Institute issued quite an atlas in this respect. Such crystalline particles may be or may not be the active effective or working particle. They do represent the minimum size and ultimate shape obtainable by mechanical dispersion.

Even careful, physical-law abiding citizens can be led astray by paying too much attention to particles which are discrete but away from "home." An example is the product of pulverizing mineral sulphur to −200 mesh for the rubber trade. Great attention was paid to the distribution of the sizes. But, examination of the sulphur *as situated* in the rubber after regular milling, showed it to be located and distributed as greatly enlarged whole crystals of sulphur. Prac-

T. G. Rochow, American Cyanamid Co., Stamford, Conn.

Registering for the Paper-Plastics Conference of TAPPI at the State University of New York College of Forestry at Syracuse, N. Y., Sept. 15 and 16, are (at table, right to left) R. T. Bingham, TAPPI; G. E. Soyka, Byron Weston Co.; E. C. Bernhardt, E. I. du Pont de Nemours & Co. Inc.; H. L. Parry, Shell Chemical Corp.; A. C. Lamoreux, Dennison Manufacturing Co.; T. A. Walb, Shell Chemical Corp.; David J. Lieb, The Borden Co., Chemical Div.; and (standing behind Mr. Bingham at right) T. G. Rochow, American Cyanamid Co.

tically all of our work of grinding and measuring the particles could have been saved. By the way, sulphur is also useful in its amorphous condition as a resin. Back in 1935, we encountered as an "unknown" a resin used to shape and stiffen paper in the form of a core for rolling paper in the mill. A very crudely abraded section showed the location of a material which was easily picked out and identified as sulphur.

Resinography started for us in 1935 when we examined some specimens of anthracite coal in polished cross section in the manner of the mineralographer. The photomicrographs at a couple hundred diameters show that coal has a distinctive texture composed of various cells, spores, and other units of biological origin. By examining the coal by ordinary reflected light and under it by cross polarizers, by dark-field, unpolarized light, and by ordinary reflected light after etching with chromic acid, we obtained various graphs by the various methods of preparation and illumination.

The natural resin of interest to most of you is rosin. Not only is rosin used together with paper, but in an extreme instance in 1935 they were confused with each other. The question was: how did paper fibers get into our company's rosin size? Microscopical examination of the sample showed that the fibers were not paper, but crystals and bundles of crystals of an elongate habit of a double salt known as "3-1 salt"—*i. e.*, three—sodium soap and one of the rosin acid. The physical and chemical properties, which made these crystals appear macroscopically like paper, were the very ones which were used microscopically to differentiate (refractive index, partial insolubility in water, ether, and alcohol) the crystalline compound from paper. As crystals, the effective particles are large but as a resin the particles are small.

The location of papermaking resins can be examined dynamically as well as statically and dynamically. Rosin size, without alum, is found to be distributed at random between and among the paper fibers and water. Addition of alum flocculates the rosin particles and the flocs become the working units which migrate to the paper fiber.

The shape of the resin and the mode of association of the pulp can give much information about the method of manufacture and the performance of material. For example, the round, hollow shape of the resin particles in one sample which was examined showed them to be spray dried from solution of the resin and the location of the wood shives within the resinous matrix indicated that groundwood was added before spray drying as a permanent, nonsegregatable filler. The composition of the V-board used during the war in shipping cases can be studied quickly by cross section with a razor blade and examination with a low-power microscope. Here will be found layers of paper of varying thicknesses in a multiple sandwich of either asphalt or urea-formaldehyde resin, as waterproof adhesives. Sometimes chemical help is needed to locate and recognize the resin. A spotted surface of a decorative laminate was examined by cross sectioning the laminate, polishing it, and adding sulphuric acid. A pink coloration, especially in the cross sections of the spotted surface areas, indicated that the coloring matter causing the spots was phenolic resin coming up from the layers of the dark filler composed of decorated paper and phenolic resin. This technique of polished cross sections can be very handy for the recognition of filling material in the resinous matrix, and to show the distribution. In the case of ground walnut shells and wheat flour incorporated in urea formaldehyde resin, the walnut cells serve to identify the manufacturer and place the responsibility of complaint from the customer, upon the right shoulders. Details of a "glue line" can be distinct and minute in some systems. Definition of the wood-morphology of wood veneers obtained from a polished cross section by reflected light is better than that obtainable by microtomed thin cross section by transmitted light and the handicap of hard, thermoset resin can be overcome. The "glue line" is differentiated from the unimpregnated wood cells by differences in both morphology and refractive indices.

Another example of differentiation is by means of refractive index (reflectivity). The molded surfaces of two resin-paper laminates provide an example. The two laminates were a pair which were produced under identical experimental conditions. We are concerned with two layers: a surface-protective layer composed of a thin sheet of paper impregnated with a resin and the other occupied by the resin-paper layer carrying the design of decoration. Black "decorative" paper was used for the experimental purpose of showing scattered light to its best advantage. On one, the protective layer was satisfactorily transparent, i.e., the design layer was displayed in almost its original degree of blackness. On the other, the protective layer scattered so much light that it almost entirely obscured the black layer. The only difference between the two samples was in the fiber composition of the paper in the protective layer: viscose fibers versus cellulose acetate fibers. The measured average refractive index of the viscose fibers was 1.545 and that of the Melmac resin was 1.652. These refractivities were sufficiently close to transmit light satisfactorily to the design layer but sufficiently different for the microscopical differentiation of the polished section. In the other, the unsatisfactory layer, not only did the cellulose acetate fibers leave a lower average measured refractive index (1.47) but they were surrounded by black bands assumed to be spaces of air, refractive index 1.000. Probably at the air-fiber and air-resin interfaces, so much light is scattered that the cellulose fibers obscure all the areas of black paper which they cover. The explanation given to the laminate experimenter is that the cellulose acetate fibers were not wetted by the Melmac resin.

Polythene is related chemically and physically to paraffin but the crystals of polythene are much finer. The fibers or flakes are approximately 620 to 250 A in short diameter, and roughly 20,000 A in length. Mr. Richards of Imperial Chemical Industries has correlated the crystalline texture with variations in chain length and degree of branching of the polymer with variations in the properties of the product. Polyethylene bridges over into the "mainland" of resins where the textural particles become smaller and smaller and their boundaries less and less definite. In some nylon, we find the crystalline grains as cast and undisturbed by fabricating processes such

as drawing and spinning. Therefore, even though the crystals are very tiny, their families or crystalline grains are quite large (in the order of several microns) and their boundaries, where one family meets another, are quite definite.

I assume that you are interested in the texture of films other than paper. In films, which are composed of very fine particles so small that they must be assumed to be the macromolecules themselves or small families thereof, these particles show differences in shape as well as size. A very thin film of a typical alkyd resin was made by casting a 0.3% solution in toluene on water and curing the film with an infrared drying lamp for about 24 hr. The cured film was mounted, metal-shadowed, and micrographed. This micrograph showed that the film was composed almost entirely of particles of macromolecular dimensions, that is 26 to 126 A. Assuming a specific gravity of 1.5, the macromolecular weight is calculated to be from 6,700 to 680,000. For comparison, a very thin film was made by using a 1/1 mixture of refined medium heat bodied linseed oil and boiled linseed oil. A micrograph showed remarkable distinction between two size groups of macromolecules. It is logical to assign the larger molecules to the bodied linseed oil with the explanation that cooking the oil gave it more body and greatly enlarged the molecule. During the air-drying of the film, there was molecular growth in both the boiled and refined constituents, but apparently, the molecules of raw oil never reach the size of the boiled part. The ranges in calculated molecular weights are as follows: presumably the bodied linseed oil: 5000 to 1,460,000; presumably the raw linseed oil: 1400 to 187,000. The occasional presence of scattered macromolecules having greater density than the majority of macromolecules in the field suggest that the molecules of drier containing heavy metallic atoms might have been incorporated into the coiled macromolecules of the linseed oil. An increase in molecular size would apparently account for increase in electron scattering and the consequent greater photographic density of the positive print. However, the presence of occasional small and large macromolecules with this condition to the same degree, affords some evidence that the high scattering power of metallic atoms may be an added factor in producing the observed differences in density of macromolecules of approximately the same size. Our curiosity led us into a study of the effect of rates of drying on the size of the macromolecules. A film was made from alkali-refined linseed oil after drying 1 week. This was compared with the same oil plus the usual amount of cobalt drier dried 1 week. Presumably, the cobalt drier cured the oil faster as the particles were of the smaller size. Next, we tried to show the size of the molecules of the uncured linseed oil. We were surprised to find particles almost as large as those in oil containing drier. After we repeated the experiment many times, we were forced to conclude that the electron beam of the microscope was curing the film. To prove this, we made a film of the oil containing an inhibitor, and as expected this time, we obtained particles very much smaller.

To return to the Rezyl + Melmac formulation, a superlatively thin film was cast and cured in the usual manner. The bulk of the film was made up of particles varying in size of 26 to 130 A corresponding to a macromolecular weight of 7100 to 920,000. There were some round areas which show smaller sizes. In these areas, we may have had concentrations of Rezyl resins. Naturally, we wished to compare the size of the particles therein to those of a molded melamine formaldehyde resin. Now we were confronted with the need for exposing the internal texture of a molded resin. After an extensive survey of methods, we chose one similar to that of Ladd who cooled a block of tire tread stock rubber in a bath of acetone dry ice and cracked the block in two. A negative replica of the broken surface was made of Duco cement or polystyrene. This was chipped off when hard and a drop of 2% Formvar solution in ethylene dichloride was placed on the negative and allowed to harden. Ladd abandoned the method because he couldn't get the replica off. We were more fortunate in using a more dispersable material like gelatin because it was readily peeled from the fracture surface and yet wetted the surface sufficiently to form a good impression. In our first results the particles were relatively large, averaging 13.0 to 300 A. This corresponds to molecular weights from 630,000 to 100,000,000. We were told by our best friends and severest critics that this was impossible. According to the best statistical approach, or call it the modern statistical approach, in the next attempt we varied everything at once, using a fast-curing melamine formaldehyde formulation and improving on the physics of the electron microscope and obtained a micrograph in which the large rounded particles appeared to be composed of groups of smaller particles which correspond roughly to macromolecular weight of 37,000 to 27,000,000. At least parts of this range are more like what the high polymer experts expected to obtain in the first place.

Apparently the molecule, the ultimate particle of characteristic matter, is one entity and another entity is the grouping of these molecules or macromolecules into actual, active, or working effective particles, especially as they are suited in the material of interests. For example, we have electron micrographed at the same magnification of PAN two widely different macromolecular weights (50,000 versus 790,000). In one the polymer is of much lower average macromolecular weight, yet the actual particles are much larger—at least they are much longer, compared with the other. A closer inspection revealed that the wormlike particles of the first were composed of the ultimate macromolecules which themselves are much smaller than the second.

I suppose, however, that you are interested most in resinography as applied to the paper industries. To get back to the case of the resin-treated paper, for many years we looked unsuccessfully for the melamine formaldehyde resin in wet-strength paper. It now appears that we were unsuccessful for two reasons: one is that in using the light microscope, we were trying to get a refraction image of the resin which was very near in refractive index to the paper fibers. The other reason for lack of success was that the particles making up the resin material were far beyond the limit of resolution of the light microscope. The ultraviolet spectroscopist, however, gave a clue to a way of locating at least the resin on wet-strength paper. He showed that melamine formaldehyde resin absorbed ultraviolet light strongly whereas paper fibers do not. Therefore, we obtained the color image by means of the ordinary microscope by illuminating with ultraviolet light in the region of 25 to 37 A. Paper fibers apparently do not absorb this lamination. The type of urea formaldehyde resin which gives wet strength to paper does not absorb ultraviolet light significantly either. Thus, the light microscope differentiates between MF and UF resins, whereas the electron microscope does not, nor does a qualitative test for nitrogen. Moreover, the quantitative estimate of the amount of MF resin might be based on its photomicrographic density, compared with that of the UF resin. To see the actual and effective particles however, the electron microscope had to be brought into play. An electron micrograph of dried resin particles of melamine formaldehyde resin treated with hydrochloric acid to form the typical colloid which is added to the beater was made. This sample was prepared by distributing the resin on a film and was shown to consist of fine roughly spherical particles varying in size from 0.06 mu down to the very limit of resolving power of the electron microscope which is about 50 A. The average size of the discrete particles is about 0.01 micron (100 A). The bulk of the material appeared to consist of a nebulous cloud of material, probably composed of particles beyond the limit of the resolution of the instrument, and forming in some areas a continuous film. At least these nebular particles are in the realm of macromolecular sizes. So much for the sizes of the particles, what is more important is the distribution on the fibers. To show this, a typical electron micrograph of moder-

H. F. Mark, Polytechnic Institute of Brooklyn; H. S. Kaufman, M. W. Kellogg Co.; R. B. Mesrobian, Polytechnic Institute of Brooklyn; T. G. Rochow, American Cyanamid Co.; Vivian T. Stannett, State University of New York, College of Forestry and secretary of the Plastics Committee; and Ralph T. Nazzaro, Westfield River Paper Co. and chairman of the Plastics Committee

ately beaten bleached kraft pulp (uranium shadowed) was made. When the same pulp treated with 3% melamine resin colloid was examined, the resin was found to be in its typically particulate form covering the fibrils in bundles of fibrils. Just as in crystallization, it takes a very thin or small piece of matter, foreign to the crystallizing material, to act as the nucleus. The rows or stringers of resin particles were very large compared with some of the fibrils acting as orienting bases.

Though we have seen that resins differ from other plastic materials such as metals, waxes, and plasters by being composed of very much smaller particles than crystalline grains, they are like their grown-up crystalline relatives in having a tendency to orient themselves into patterns, as macromolecules or their groups. An example of pure curiosity in this regard, are the organo-germanium oxides which may be prepared from organo-germanium chlorides by a method somewhat analogous to those employed for the preparation of methyl chlorosilane. Methyl or ethyl chloride is passed through a heated mass of powdered metallic germanium to which has been added 20% copper, and methyl ethyl germanium dichloride is isolated from the condensate in good yield. Hydrolysis of the dialkyl germanium chloride produces polymeric organo-germanium oxides or "germaniones" which are somewhat water-soluble but have other properties suggestive of the silicones. This material is generally obtained as an oil which contains many molecular species, some quite volatile and some of higher molecular weight, which crystallize after evaporation of the volatile material. When some of this oily or waxy material is smeared on glass slides the macromolecules or their small groups arrange themselves into patterns or crystals. These crystals bear a striking resemblance to crystals of a mosaic virus as electron micrographed by Wyckoff. The similarity raises a question of whether or not the crystals of synthetic polymers might be isomorphic with virus crystals and if so whether the macro crystals would interfere with the growth or function of these viruses. If so, not only have we related resins to highly crystalline plastic materials, but also to the smallest living self-reproducible material, the virus.

Chairman Mark: Thank you very much Mr. Rochow. One particularly impressive result seems to be the excellent way in which this method demonstrates the higher tendency of low molecular weight species of a given polymer to crystallize than the higher molecular weight species. It may be the reason why low molecular weight constituents which sometimes have been thought to act like plasticizers do not act that way but rather like "embrittlers." They do that because the shorter chains attach to each other more easily than the longer ones.

Mr. Rochow: That would explain the association of like for like. The islands of smaller numbers among the larger ones—how would you explain that?

Chairman: There exists an analogous case in the behavior of a pulp sheet which contains low molecular weight constituents; under the influence of alkalis, they show a tendency to fuse together and to form brown spots.

Mr. Rochow: The lower mass of lower molecular weight species, or the higher specific surface, or the greater activity?

Chairman: These constituents are smaller and hence diffuse more rapidly and when they are attached to a nucleus, they never get away again.

If there are no other remarks right now, I am sure there will be some later.

Let's go to the next speaker who is Mr. Mesrobian, who got his Ph.D. at Princeton and who is now working at the Polytechnic Institute. He will also talk about a new type of macro molecules—about the so-called "block and graft copolymers." Mr. Mesrobian.

Block and Graft Copolymers

R. B. MESROBIAN

Summary

The various methods employed to present data in the preparation of block and graft copolymers were reviewed. The methods employed are as follows:

1. Block copolymer
   - A. Use of expansion agents
   - B. Co-condensation of primary blocks
   - C. Second stage vinyl polymerization
     - (a) Flow system technique
     - (b) Post polymerization technique
     - (c) Labile end group technique
2. Graft copolymers
   - A. Styrenation of unsaturated polyesters
   - B. Chain transfer technique
   - C. Side chain polymerization
   - D. Use of polymeric hydroperoxides

In several cases, commercial products are on the market which have been prepared by one of the above-mentioned techniques. The properties of these block and graft copolymers are comparable with the expected mechanical or solution behavior of copolymers.

Chairman: I thank you very much for this summary of what evidently is a very interesting field of two types of molecules.

Mr. Frisch: I'd like to know whether any inorganic polymers have been used in forming graft polymers.

Mr. Mesrobian: Inorganic polymers such as those containing silicone? I don't know of any.

Mr. Saul: In the blending of two vinyl polymers, do you accomplish a property of block polymerization?

Mr. Mesrobian: If one could really blend the two, then you may get these properties.

Mr. Saul: Do they blend under extreme mechanical conditions?

Mr. Mesrobian: You take two polymers such as polystyrene and natural rubber—both soluble in benzene—and you pour the two together and they co-precipitate each other. There are extremely few examples where two polymers show compatibility in the presence of each other. So that if you make a mechanical blend of two polymers, I

don't think you will get better physical properties because they are incompatible. If, however, by severe mechanical treatment you get a true copolymer—perhaps by mechanical breakdown of network chains which then recombine to form block or graft structures—then one might expect enhanced mechanical behavior in the product.

CHAIRMAN: For the time being I think the audience is satisfied with your explanation. Thank you again very much.

Now, we are just on time and I'd like to ask our next speaker, Mr. Walb from the Shell Chemical Corp., to tell us something about the very interesting and important new group of epoxy resins, which you will see are something approaching block or graft copolymers and many other examples Mr. Mesrobian mentioned. Mr. Walb!

Epoxy Resins

T. A. WALB

HIGH POLYMERS represent the fastest growing segment of the American chemical industry and the purpose of this article is to review some of the highlights of epoxy resins, one of the more recent important developments in this rapidly expanding field.

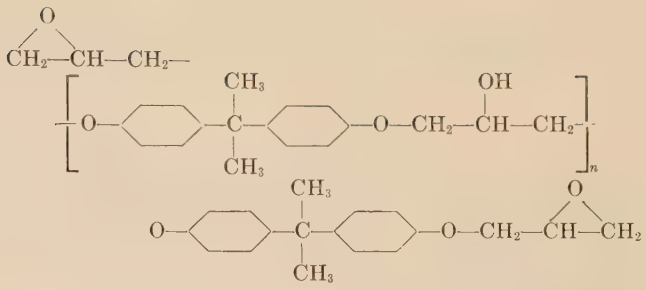
As in the case of many of the established commercial polymers epoxy resins experienced a rather lengthy period of gestation. Although a di-epoxy compound was prepared as early as 1891, many years elapsed before methods were developed for the manufacture of epoxy resins and the versatile utility of the new products was recognized. Another significant factor in this time lag was the unavailability of raw materials in sufficient quantity and at a suitable price. With the commercial availability of epichlorohydrin from Shell Chemical in 1946 at a price competitive with other polymer raw materials epoxies were able to shed their "laboratory curiosity" tag.

Development of these resins in commercial applications was the result of independent research by Ciba Co., Inc. in Switzerland and Devoe and Raynolds Co. in the United States. Ciba's original interest was mainly concerned with adhesive formulations while Devoe and Raynolds worked primarily with surface coating applications. As a logical extension of its position as a raw material supplier of epichlorohydrin Shell Chemical in 1946 began marketing of this new class of polymers under the trade name of EPON® resins. Since then the over-all U. S. yearly production of these resins has grown tremendously. Shell Chemical is presently making a very substantial increase in production capacity for EPON resins as well as expanding facilities for the manufacture of epichlorohydrin and bisphenol A, the other major raw material.

All the basic organic raw materials for EPON resins can be derived from petroleum. For reaction with epichlorohydrin, bisphenol A is widely used, although useful resins are possible using other polyols, both aliphatic and aromatic. Epichlorohydrin is made from propylene via allyl chloride. Bisphenol A is made from acetone and phenol, the precursor for the former is propylene and for the latter benzene.

CHEMISTRY AND PHYSICAL PROPERTIES OF EPOXY RESINS

The structure of epoxy resins is ideally represented by the formula:



It will be noted that there are $n + 2$ reactive groups in each molecule, the illustration depicting three such groups, two epoxides and one secondary hydroxyl group. It is the epoxide group that contributed the generic name to these resins.

The comercial resins are mixtures of polymers wherein n varies between 0 and 10. These resins range from viscous liquids to hard tough solids. In the liquids which are the lowest molecular weight n equals 0 for most of the molecules. Resins of intermediate molecular weight where n equals 2 to 3 are easily frangible solids.

Several characteristics can be postulated from a consideration of this chemical structure which are reflected in the outstanding properties of the epoxy resins. It will be observed that the only linkage other than C to C is through C to O bonds. Inasmuch as the ether linkage is among the more stable known to organic chemists it is not surprising to find these resins highly resistant to attack by water, various solvents, acids, alkalies, and other chemicals.

The reactive groups are epoxides and hydroxyls which are the points of reaction with catalysts and curing agents to promote three dimensional polymers. These reactive groups are comparatively widely spaced resulting in unusual toughness and flexibility in the cured polymer compared with other thermosetting resins.

The polar nature of the molecule contributes to adhesion. The low shrinkage on curing (a mechanism which will be discussed later) is also a contributing factor to adhesion. Pure liquid epoxy resins cured with amines show a shrinkage less than 4%, approximately one half of which takes place after gelation. This shrinkage is much lower than that of most thermosetting polymers.

The molecule is sufficiently balanced electrically to make these resins applicable for the casting and potting of electrical components. The resins show good color and color retention,

Table I

Resin type	*Melting point,[a] °C.*	*Color[b] (Gardner)*	*Viscosity[b] (Gardner-Holdt)*	*Epoxide equivalent[c]*
		Sales Specifications		
EPON 562	Liquid	5 max.	C-F	140–165
EPON 828	Liquid	12 max.	Z_5-Z_6+	190–210
EPON 834	Liquid	10 max.	A_2-A_1	225–290
EPON 864	40–45	8 max.	A_1-B	300–375
EPON 1001	64–76	8 max.	C-G	450–525
EPON 1004	95–105	6 max.	Q-U	870–1025
EPON 1007	127–133	8 max.	Y-Z_1	1550–2000
EPON 1009	145–155	11 max.	Z_2-Z_5	2400–4000

General Properties

The following data are values taken from representative lots.

EPON resin type	562	828	834	864
Physical appearance (room temp.)	Liquid	Viscous liquid	Semi-solid	Semi-solid
Weight per gal. (lb.)	10.25	10.27	9.72	9.89
Refractive index (20°C.)	1.478[e]	1.573	1.583	1.592[e]
Equivalent weight[d]	65	85	105	115
EPON resin type	1001	1004	1007	1009
Physical appearance (room temp.)	Solid	Solid	Solid	Solid
Weight per gal. (lb.)	10.05	9.63	9.56	9.92
Refractive index (20°C.)	1.595[e]	1.600	1.598	1.601
Equivalent weight[d]	145	175	200	220

T. A. WALB, Shell Chemical Co., New York, N. Y.

[a] Durrans' mercury method.
[b] EPON 562 and EPON 828 on solid resin, all other types, on 40%w solution in butyl carbitol at 25°C.
[c] Grams of resin containing 1 gram-equivalent of epoxide.
[d] Grams of resin required to completely esterify 1 gram-mole of monobasic acid, e.g., 280 grams of C_{18} fatty acid or 60 grams of acetic acid.
[e] At 25°C.

Table II. Approximate Viscosity, Pot Life, and Recommended Cure Schedule for Liquid EPON Resins Containing Various Curing Agents

Curing agent	Conc., phr	EPON 828 — Room temp. — Viscosity, cp.	EPON 828 — Room temp. — Pot life[a]	EPON 828 — 50°C. — Viscosity cp.	EPON 828 — 50°C. — Pot life	Recommended cure — Time, min.	Recommended cure — Temp., °C
Tri(dimethylaminomethyl)phenol (DMP-30)	6	21,000	29 min.	3260	18 min.	60	80
Diethylenetriamine	8	3,000	53 min.	440	8 min.	30	115
Dimethylaminopropylamine	6	4,000	55 min.	2740	18 min.	60	80
Dimethylaminomethyl phenol (DMP-10)	16	5,000	60 min.	1850	24 min.	60	80
Dimethylethanolamine	6	10,000	80 min.	970	8 min.	30	100
Diethylaminopropylamine	6	4,500	210 min.	720	130 min.	60	115
Benzyldimethylamine	6	7,000	229 min.	2160	175 min.	60	80
Diethylamine	12	400	>6 hr.	100	6 hr.	150	115
Pyridine	15	800	>25 hr.	1500	4 1/2 hr.	120	80
Piperidine	6	6,000	>6 hr.	80	5 hr.	180	80
Dimethylaminopropionitrile	6	6,000	>6 hr.	510	3 1/2 hr.	120	80
None	..	10,000	...	800	...	...	...

[a] Time required to reach 100,000 cp. above which viscosity mixture too thick for manipulation.

the phenolic hydroxyl group, often the source of color difficulties, having been blocked by conversion to an ether linkage.

Physical properties and sales specifications of a series of EPON resins are given in Table I.

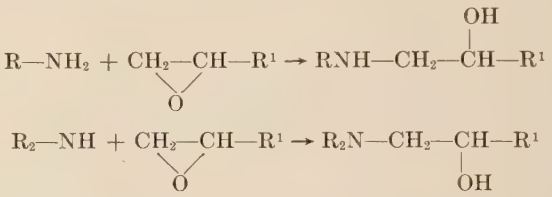
Unreacted EPON resins have shown limited utility in the end uses investigated to date. The outstanding properties which make epoxies useful are obtained by chemical reaction with curing agents which convert these resins to chemically and mechanically strong polymers by building the largest possible molecular units. The resins may be cured in the unmodified state or in the modified state following reaction with fatty acids to form esters.

Curing of the unmodified resin is accomplished in general with any compound having active hydrogen. Both hydroxyl and epoxide groups are involved in this reaction with the latter probably playing the more predominant part. Considerable work remains to be done regarding the curing mechanism. However, for the purpose of this review interest can be largely confined to the epoxide groups which are generally cured by reaction with amino, carboxyl, or hydroxyl groups and inorganic acids to give secondary hydroxyl groups and a bond from the remaining epoxide carbon atom to the nucleus of the donor. Advantage of the last mentioned reaction is taken in the stabilization of polyvinyl chloride polymers by scavenging of free hydrochloric acid, a significant commercial use for epoxy resins. The secondary hydroxyl group undergoes typical reaction with acids and anhydrides.

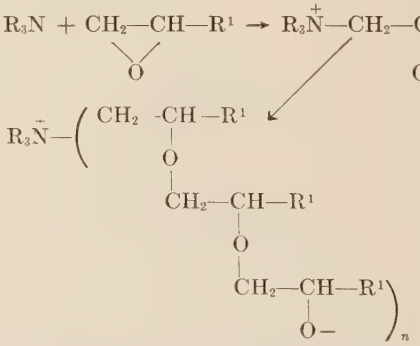
Curing of epoxy resins by the use of heat alone has not been successful to date. Amines, acid anhydrides, dibasic acids, and resins including phenol formaldehyde, urea formaldehyde, polyamides, and melamine formaldehyde are typical of commercial curing agents.

Amines are one of the more important types of curing agents and the catalytic reaction of these derivatives with the epoxy groups can be explained by the reactions shown below.

A primary or secondary amine undergoes a straightforward reaction with the epoxy group giving a secondary or tertiary amine and an alpha hydroxyl group.



The nitrogen of a tertiary amine can further react with an epoxy ring to form a quaternary ammonium compound followed by chain propagation:

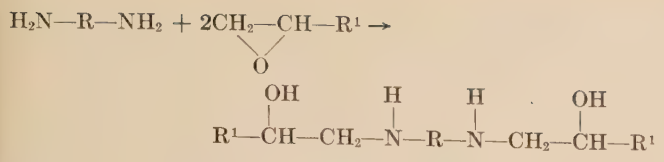


Polyfunctional primary and secondary amines can function as catalysts by the mechanism set forth above or as cross-linking agents by the reaction:

Table III. Approximate Viscosity, Pot Life, and Recommended Cure Schedule for Liquid EPON Resins Containing Various Curing Agents

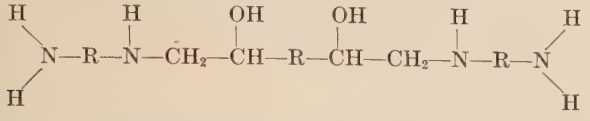
Curing agent	Conc., phr	EPON 834 — Room temp. — Viscosity, cps.	EPON 834 — Room temp. — Pot life[a]	EPON 834 — 50°C. — Pot cps.	EPON 834 — 50°C. — Viscosity, life[b]	Recommended cure — Time min.	Recommended cure — Temp., °C.
Tri(dimethylaminomethyl)phenol (DMP-30)	6	[a]	...	55,000	<10 min.	60	80
Diethylenetriamine	8	[a]	...	8,000	<10 min.	30	115
Dimethylaminopropylamine	6	[a]	...	30,000	<10 min.	60	80
Dimethylaminomethyl phenol (DMP-10)	16	[a]	...	4,000	<10 min.	60	80
Dimethylethanolamine	6	[a]	...	10,000	30 min.	30	100
Diethylaminopropylamine	6	[a]	...	7,000	<30 min.	60	115
Benzyldimethylamine	6	[a]	...	7,000	<20 min.	60	80
Diethylamine	12	4,000	...	400	<45 min.	150	115
Piperidine	6	[a]	...	1,000	<30 min.	180	80
Dimethylaminopropionitrile	6	[a]	...	6,000	<70 min.	120	80
Pyridine	15	2,500	...	600	3 1/2 hr.	120	80
None	..	>100,000	...	16,000	...	...	...

[a] Greater than 100,000 cp.
[b] Time required to reach 100,000 cp. above which viscosity mixture too thick for manipulation.



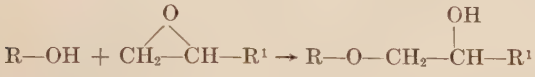
When the R^1 groups in the foregoing reaction contain other epoxy linkages as is the case with epoxy resins the reaction gives cross-linked, thermoset polymers.

It is readily seen that a long chain can be formed if the ratio of diamine molecules to resin molecules is 1 to 1 and that less than the equivalent quantity of diamines will cause gaps in the chain, while adding two diamine molecules for each resin molecule can result in each resin molecule reacting with an amine group without any coupling being accomplished, yielding the compound:



This demonstrates the importance of adding the correct amount of curing agent since coupling to obtain the largest possible structure is the aim of curing.

Other reactions which can assist in accomplishing cure include opening of the epoxide ring by one of the hydroxyl groups on the resin in the following manner:



Here the epoxide group forms another OH group by gaining hydrogen from the donor. This new hydroxyl can in turn open another epoxide group, the process being repeated many times to build a super molecule. Although reaction with hydroxyl is less apt to occur than with amino groups, it may be an important part of cure under alkaline conditions and at elevated temperatures.

The curing process with amines may be summarized as follows:

1. The amino group reacts with an epoxide group at room temperature.
2. Polyamines by themselves or those produced in the initial reaction can couple epoxy resins.
3. At elevated temperatures and in the presence of certain amines other coupling reactions such as those involving the OH groups can also be important.

A summary of the approximate viscosity, pot life, and recommended curing schedules for various amines and liquid EPON resins 828 and 834 is given in Tables II and III.

Dibasic acids are also useful in curing epoxy resin molecules by esterification of hydroxyl groups giving the usual by-product, water. Coupling can occur if the two esterified hydroxyl groups are situated on different resin molecules. Acids may also react with an epoxide group by donating a hydrogen with the formation of an ester linkage. The total cure by an acid anhydride is probably a mixture of the two mechanisms mentioned. In general, cure with acids requires higher temperatures than those needed for curing with amines.

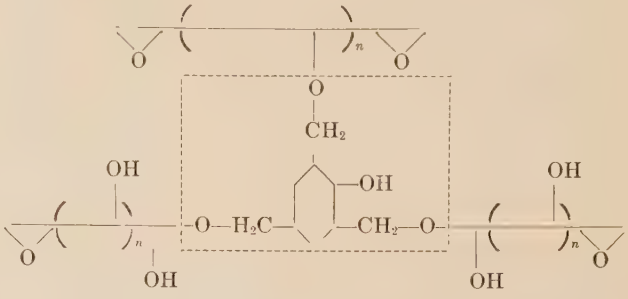
Urea, melamine, and phenol formaldehyde resins are widely used, particularly in surface coatings, to copolymerize or cure epoxy resins. The reaction is believed to involve the methylol group with both the hydroxyl and epoxy groups. The following postulates the mechanism of the reaction of EPON resin with a phenolic resin.

Epoxy resins cooked with fatty acids are generally referred to as modified. The preparation of these esters is very similar to that of alkyds and the esters likewise resemble alkyds in certain respects. If nondrying fatty acids are used the resulting esters can be combined with urea or melamine formaldehyde resins into coatings with excellent properties for baking applications. When drying oil fatty acids such as linseed, soya, and dehydrated castor are used in esterification the esters are capable of air oxidation and curing via the usual drying oil mechanism. As in the case of alkyds the drying oil esters can be styrenated for special uses.

APPLICATIONS

Surface Coatings

The bulk of EPON resins presently find their way into surface coating end uses and the following systems are most widely used.



1. EPON-phenolic: This system which requires a heat cycle of 10 to 60 min. at 400 to 300°F for cure offers the optimum in chemical resistance coupled with excellent adhesion and flexibility. Whites and pastel colors are not possible because of the color contributed by the phenolic resin. Applications for this vehicle include drum linings, coatings for chemical processing equipment, storage tanks, piping, laboratory and hospital furniture.

2. EPON-ureas: This system which likewise requires a baking schedule, 20 to 60 min. at 300 to 250°F., to effect cure combines the properties of excellent color and color retention with good chemical resistance. Applications include appliance, can, metal decorating, and clear metal finishes.

As with the EPON-phenolic system the baking schedules here are not very adaptable to commercial paper coating operations. Both of these systems probably lack the desired flexibility for most paper coating uses.

3. EPON-amine: This system using ethylene diamine or diethylene triamine can be cured by air dry or by force dry for 4 to 90 min. at 350 to 140°F. It is possible with this combination to obtain baked coating properties in an air-dried film. The system is of potential interest to paper coaters for the preparation of cap and seal liner, greaseproof barrier, as a release coating for casting polyvinyl chloride films, and other applications where chemical resistance is desired. Full cure in the coating operation is not required. In paper coating it is only necessary to use sufficient heat to prevent blocking, the cure completing on storage of the coated rolls at room temperature.

EPON resins can be cured with polyamide resins of the type offered by General Mills. Compared with other amine curing agents previously mentioned polyamides by virtue of their longer chain length offer improved flexibility in combination with epoxy resins and this property is of interest to those working with epoxies in paper coating.

4. EPON-esters: Like oil modified alkyd resins, EPON esters prepared from nondrying fatty acids must be combined with urea or melamine formaldehyde resins and baked to give desirable properties for most surface coating applications while esters prepared with drying fatty acids can be cured by air dry or baking. The speed of cure as in the case of alkyds containing similar oil components is largely dependent on the type of drying acid used. Baked drying fatty acid esters give the best adhesion and flexibility of the epoxy surface coating systems.

EPON resin surface coating systems can be listed in the following order of increasing hardness and decreasing flexibility: air dried esters (softest and most flexible), baked esters, amine cured formulations, urea formaldehyde and phenol formaldehyde (the hardest and least flexible).

EPON-esters are used in spar floor varnished, automotive and furniture finishes, can linings, concrete paints, porch and deck enamels, etc.

Structural Uses

In the nonsurface coating field EPON resins are gaining widespread use in casting and potting, adhesive formulating, laminating, and foaming applications.

Casting and Potting. The expanding use of electrical and electronic equipment in both military and civilian applications has resulted in more severe operating conditions such as increased range of service temperature. In the past radio equipment and aircraft control devices, requiring protection from the elements, were sealed in oil-filled containers or embedded in tars, pitches, waxes, and similar materials. These materials of protection are unsuitable for many of the more rigid operating conditions and are being replaced by plastics.

Because of their desirable physical and chemical properties epoxy resins are finding increasing use in encapsulating and potting of such equipment. Their low shrinkage on curing, about 2% before gelation and 2% after gelation, permits their use in embedding vacuum tubes, miniaturized electronic circuits, and other delicate equipment, and their low cure temperature and exothermic heat of reaction do not deleteriously affect the operating characteristics of many components in electronic circuits.

Tables IV and V list some physical and electrical properties of unfilled cast EPON resin 828.

The excellent adhesion of EPON resins to many materials has resulted in the development of high strength metal to metal adhesives which can be cured at moderate temperatures requiring only contact pressure. Such adhesives have been of primary interest to aircraft manufacturers, particularly for bonding of aluminum. While EPON adhesives are most widely used in metal to metal bonding they can be used to bond a variety of materials to themselves and to each other. Practically all materials excluding polyethylene, plasticized polyvinyl chloride, silicones, and fluorinated thermoplastic polymers can be bonded with EPON adhesives. No volatiles are produced in the cure and consequently "blown joints" due to expansion of vapors, a problem with adhesives applied from solvents or those based on condensation resins such as phenolics, which produce water upon curing, are largely eliminated.

Table IV. Physical and Chemical Properties of the Cured Resin (Measured at 25°C. (77°F.) Unless Otherwise Noted)

Specific gravity 20/20°C	1.19
Barcol hardness	36
Thermal coefficient of expansion, linear (ASTM D 696–44)	6.7×10^{-5}/°C.
Coefficient of thermal conductivity	
Cal./sec./cm.²/°C./cm	4.8×10^{-4}
B.t.u./sec./ft.²/°F./in.	3.9×10^{-4}
Water absorption (ASTM D 570–42), %	
24 hr.	0.07
1 wk.	0.20
1 mo.	0.47
Water vapor transmission (g./sq. meter/24 hr. on a 10-mil film at 77°F., 0% R.H. one side, 50% R.H. on other)	1.0
Stability to chemicals (ASTM D 543–43), percentage gain in weight after 1 mo.'s immersion in:	
Ethyl alcohol	0.75
Benzene	0.26
Aging: Weight loss of 1/8-in. sections after conditioning at 50% R.H. and 77°F., %	
18 hr. at 85°C.	0.026
16 hr. at 195°C.	1.05
Tensile strength (ASTM D 638–49 T), p.s.i.	8000
Elongation, %	1.6
Modulus, p.s.i.	0.66×10^6
Tensile strength at 54°C., p.s.i.	8800
Elongation, %	1.5
Modulus, p.s.i.	0.53×10^6
Tensile strength at −57°C., p.s.i.	9000
Elongation, %	1.7
Modulus, p.s.i.	0.65×10^6
Compressive strength (ASTM D 695–49 T),	18,400
Compression, ultimate, %	5.5
Flexural strength (ASTM D 790–49 T), p.s.i.	21,000
Modulus, p.s.i.	0.54×10^6
Impact strength, Izod (ASTM D 256–47 T), ft.-lb./in. of notch	0.36

Table V. Electrical Properties of the Cured Resin (Measured at 25°C. (77°F.) Unless Otherwise Noted)

	—50% relative humidity—		After 24 hr. in water (sample 1/8 in. thick)	
Frequency	*Dielectric constant*	*Dissipation factor, tan delta*	*Dielectric constant*	*Dissipation factor, tan delta*
Dielectric Constant and Dissipation Factor (ASTM D 150–47 T)				
10^2	3.8	0.0023	3.9	0.002
10^3	3.8	0.0035	3.9	0.003
10^4	3.8	0.0064	3.8	0.007
10^5	3.7	0.010	...	...
10^6	3.7	0.015	...	...
10^7	3.8	0.019	...	...
10^9	3.0	0.015	...	...
10^{10}	2.8	0.025	...	...

Electrical Resistance (ASTM D 257–49 T)	
Surface resistivity	9.4×10^{13} ohms
After 24 hr. in water	8.7×10^{13} ohms
Volume resistivity, 50% R.H.	
25°C.	8.7×10^{14} ohm-cm.
100°C.	5×10^{11} ohm-cm.
150°C.	1×10^9 ohm-cm.
200°C.	1.3×10^8 ohm-cm.
Arc resistance (ASTM D 495–42)	240 sec.
Dielectric strength (ASTM D 149–44)	400–500 v./mil

Superior to most cast materials in actual high voltage applications due to absence of corona as a result of exceptional adhesion to metal. A trial test with actual equipment is strongly recommended.

The following are typical block shear strengths observed in bonding various materials with EPON adhesive VI using diethylaminopropylamine as the curing agent, cure schedule 200° for 45 min. are given in Table VI.

These data were obtained by heat curing. Bonding can be carried out at room temperature with various amine curing agents with some sacrifice in bond strength as compared with heat curing.

Laminating. In the structural field laminating appears to offer the best potential for epoxy resins. Three techniques are of primary interest:

1. Wet lay-up involving the use of 100% reactive liquid resins with proper curing agents.

2. Dry lay-up in which the solid resins and their curing agents in suitable solvents are used to pre-impregnate the reinforcing medium. The impregnated stock is then dried to remove solvent and subsequently cured by heat and pressure after cutting to the desired laminating form.

3. Hot melt systems which differ from the preceding

Table VI

Sample	*Average block shear, p.s.i.*
Steel to steel	5100
Lucite to lucite	800
EPON fiberglas laminate to EPON fiberglas laminate	5500
Aluminum to aluminum	6400
Bakelite to bakelite	3900
Steel to EPON fiberglas laminate	5100
Steel to aluminum	6400
Steel to bakelite	3700
Valve bronze (composition M)	5000
Copper nickel (70/30)	5500
Copper	3500

Table VII. Flexural Strength of 181-114 Glass Cloth Laminates Containing EPON 828, Cured with Miscellaneous Amines

Curing agent	*Conc., phr*	*Resin, %*	*Cure time, min.*	*Cure temp., °C.*	*Cure pressure, p.s.i.*	*Flexural ult., p.s.i.*
Dimethylaminomethyl phenol (DMP-10)	16	30	60	80	25	55,200
Dimethylaminomethyl phenol (DMP-10)	16	26	60	80	25	48,800
Dimethylaminomethyl phenol (DMP-10)	16	31	60	115	25	48,100
Tri (dimethylaminomethyl) phenol (DMP-30)	6	32	60	80	25	37,700
Tri (dimethylaminomethyl) phenol (DMP-30)	6	32	120	80	25	51,000
Tri (dimethylaminomethyl) phenol (DMP-30)	6	27	60	115	25	50,300
Diethylamine	12	26	180	115	25	49,600
Piperidine	6	32	180	80	25	52,500
Dimethylaminopropionitrile	6	31	120	80	25	55,900
Pyridine	15	32	120	80	25	63,800
Dicyandiamide	6	25	30	165	25[a]	69,000
Dimethylethanolamine	6	29	30	100	25	59,800
Dimethylethanolamine	6	29	30	100	25	56,600
Dimethylethanolamine	6	30	15	100	25	55,600
Dimethylethanolamine	6	26	15	115	25	63,500
Dimethylethanolamine	6	28	30	115	25	61,100

[a] Includes 5 min. preheat at contact pressure.

technique in that the stock is not impregnated from solution but is dusted with powdered resin which has previously been thoroughly mixed with a curing agent by ball-milling.

Liquid Lay-up. Flexural strength of properties of 181-114 glass cloth laminates containing EPON 828 cured with various amines are shown in Table VII.

The wet lay-up technique is of interest because it provides a means of obtaining low temperature cures with liquid amines. Although the maximum strength properties available from EPON resins are not developed during low temperature cures the parts cure sufficiently well at these temperatures to allow release from their molds. The parts can then be subsequently aged at higher temperatures with conventional heating equipment to develop full strength. Liquid lay-up is being used, both in bag molding and in fabrication with matched metal dies. This technique has also been found convenient for the production of piping and tubing from glass yarn or roving. The reinforcing material is wound on a mandrel and the catalyzed liquid resin applied by brush, squeegee, or roll as the work progresses.

The outstanding properties of the EPON resin glass fiber tubes appear to be leak resistance at high pressure and superior shear strength. Data on burst pressure of glass filled epoxy pipes show that hoop strengths in the range of 70,000 p.s.i. can be obtained.

Dry Lay-up Laminating. The use of glass cloth pre-impregnated with solid EPON resins and suitable curing agents has probably received the most widespread attention. Table VIII shows typical properties of laminates produced from solid EPON resins and 181-114 glass cloth using dicyandiamide as the curing agent.

Most interest in dry lay-up lamination has been in the electrical field, particularly in printed circuitry where it is possible to make an EPON resin laminate and adhere metal foil to its surface in one press operation. The resulting laminate has good wet and dry electricals, high service temperature, and excellent machining properties for shearing punching, drilling, etc. Some data on the electrical properties before and after aging of a commercial EPON resin, glass reinforced copper clad laminate, are given in Table IX.

Hot Melt Application. Because the difficulty of evenly distributing powdered resin over the reinforcing medium can result in comparative nonuniformity and poor reproducibility as regards high strength the powder method is considered less attractive from a mechanical application standpoint than either liquid lay-up or dry lay-up via solvent impregnation. Hot melt application will probably find its widest application in matched metal die work where unidirectional glass mat, roving or random fiber preforms are introduced into the mold cavity with subsequent dusting of the

Table VIII. Properties of Laminates Produced from Solid EPON Resins and 181-114 Glass Cloth Cured with Dicyandiamide

Curing conditions; contact pressure at 165°C, for 10 min., followed by 25 min. and 200 p.s.i. at this same temperature

Flexural	
Ult., p.s.i.	76,900
Mod., $\times 10^{-6}$	3.72
Yield, p.s.i.	69,600
Tensile	
Ult., p.s.i.	55,300
Mod., $\times 10^{-6}$	3.54
Yield, p.s.i.	55,300
Compressive	
Ult., p.s.i.	70,200
Mod., $\times 10^{-6}$	4.26
Yield, p.s.i.	62,900
IZOD impact, ft.-lb./in.	17.4
Flammability, in./min.	Self-extinguishing
Water absorption, 24 hr., %w	+0.03
Rockwell M hardness	111
Specific gravity	1.91
30-Day wet strength, flex.	
Ult., p.s.i.	71,300
Mod., p.s.i. $\times 10^{-6}$	3.7
60-Day wet strength	
Ult., p.s.i.	64,600
Mod., p.s.i. $\times 10^{-6}$	3.7

Table IX. Electrical Properties of a Commercial EPON Reinforced Glass Cloth Copper Clad Laminate

EPON 1001 impregnated 128-114 glass cloth containing 6 phr dicyandiamide cured at 25 p.s.i., 165°C. for 25 min. after a 5-min. precure at contact pressure. Laminate approx. 1/10 in. thick covered both sides with copper foil

	Before aging	*After aging at 350°F. for 10 hr.*
Surface resistivity, ohms cm./cm.	3.22×10^{13}	1.29×10^{14}
Arc resistance, sec.	254	245
Arc resistance, sec.	...	253[a]
24-hr. water absorption, %	0.016	0.034

	Dissipation factor		*Dielectric constant*	
Frequency	*Before aging*	*After aging 10 hr. at 350°F.*	*Before aging*	*After aging 10 hr. at 350°F.*
10^2	0.017	0.005	5.65	5.28
10^3	0.009	0.0045	...	5.23
10^4	0.008	0.0055	5.49	5.17
10^5	0.010	0.0075	...	5.10
10^6	0.043	0.020	5.26	5.00
10^7	0.045	0.040	...	4.90
10^8	0.039	0.030	5.08	4.80

The surface resistivity tests were made at 500 v.
[a] On section protected by copper foil during aging.

catalyzed powdered resin. This technique also shows some promise in tube and pipe manufacture utilizing heated mandrels and web preheating shoes in common use with other solid resins.

Data reported on laminating are confined to glass cloth as the reinforcing agent, this material having received most attention to date from those working in this field. However high strength laminates have also been prepared from glass mat, glass roving, and alpha cellulose. Kraft paper tends to inhibit curing with dicyandiamide and laminates so far prepared with this system have not shown much promise.

Foams. EPON foams are still largely in the experimental stage. However, foams in volume up to 2 cu. ft. can be readily prepared by mixing resin, curing compound, and foaming agent such as Celogen at the proper temperatures. Foams with densities of 1 to 15 lb. per cu. ft. have been prepared. Foamed EPON resins retain the excellent chemical resistance of solid or film types. Their predominantly unicellular nature makes them of potential use as buoyancy materials and as foamed-in-place casts or embedments where weight saving is a significant factor.

Some of the more prominent surface coating and structural uses for this new class of resins have been presented. Their versatility and unique properties have attracted the attention of many research and development chemists and it is expected that EPON resins will find a prominent place among the longer established thermosetting plastics.

CHAIRMAN: Are there any questions?

MR. LINDSFELDER: Is there any residual epoxy content in amine cured epon resins?

MR. WALB: We have reason to believe there are some remaining epoxide groups in amine cured systems. Developing accurate methods of detecting these groups, in cured systems as you probably appreciate, is rather difficult. We have done a fair amount of work and are evolving techniques.

QUESTION: Have you any experience in the reaction of epoxy resins with cellulosic fibers to make wet-strength papers?

MR. WALB: I have no direct knowledge of such use and don't know of anybody who is working along that line. From the preliminary work that has been done in connection with paper and paper laminates, I think I mentioned that, to date, most of our experience and I believe that most of the experience of others, has been with glass as a reinforcing agent. The resins don't seem to help paper as well as they do a lot of other materials. I can see where there might be some difficulty, particularly in the higher molecular grades, in penetrating the cellulose fibers and that even the lower molecular weight grades might be too large to freely permeate the fiber structure.

CHAIRMAN: Does anybody in this group have experience on these questions? Maybe somebody else has tried it.

ANSWER: I tried it and it doesn't work. We have tried it with rayon fibers with some success.

CHAIRMAN: I think Mr. Walb pointed out that the lowest molecular weight resin, essentially a monomer, is already rather large as compared with the melamines. These resins are rather large molecules already and hence probably the diffusion into the interior of the fiber of a strongly twisted yarn may not be so easy.

But, in the case of glass fibers, of course, the resin wets the surface—which it does very readily. It can't get into the fiber anyway.

QUESTION: You say you use it for a surface coating on paper. Is the adhesion bad?

MR. WALB: No. The adhesion of coatings on paper is very good. As I mentioned, for some paper coating, the phenolic and urea converted systems probably are lacking in flexibility although the combination with amines, particularly polyamides, does give very flexible paper coatings and is actually in commercial use. Phenolic and urea cured coatings have not attracted too much interest. I think primarily because the cure cycle is too long for paper coatings.

QUESTION: Is the cure cycle long with amines and polyamides too?

MR. WALB: No. It can very easily be done on a paper coating machine. Full cure requires a baking cycle of 4 to 90 min. at 350 to 140°F. However, it is not necessary to fully cure in the coating operation—only sufficient cure to avoid blocking so that you can roll the stock and store it and reach the final cure under room temperature storage. The system has a very high gloss and pigments very well and can be used for decorative purposes.

QUESTION: Can you use it in dispersions?

MR. WALB: Aqueous dispersions have been made quite easily. We ourselves have not done too much along that line.

QUESTION: Do they seem to be stable?

MR. WALB: I would say from our preliminary experiments that you could make reasonably stable dispersions. We haven't studied that phase in detail.

CHAIRMAN: I think we should, at this point, at least thank you very much again and I don't want to conclude, but will interrupt, the discussion while we go to lunch. (Whereupon the meeting recessed at 12:15 p.m.)

Survey of Progress in the Field of Unsaturated Polyesters

F. R. EIRICH and M. SILBERBERG

EARLY interest in polyesters stems from the work of Carothers (*1*), who in the 1930's investigated both linear polyesters and polyamides, but abandoned the former for industrial use because of easy hydrolysis. At the same time kinked and cross-linked polyester chains in the form of alkyds, including those of a drying nature, were widely used commercially but their development was stagnant, due to inherent inadequacies in composition. The widespread acceptance of polyesters today stems from three advances: (1) gradual recognition that more symmetrical components would lead to crystalline, and hence to less easily hydrolyzed, resins of superior mechanical properties; (2) an appreciation of the importance of careful stoichiometry; and (3) further variation of product preparation and properties by means of built-in unsaturation. As a result, the polyester field today can claim numerous excellent resins of easy cure and practically unlimited application.

POLYESTER RESIN COMPONENTS

The formation of polyesters is, as is well known, based on the condensation reaction between di- or polybasic acids, or their anhydrides, and glycols or polyalcohols, the reactants being chosen so as to exclude the formation of five- and six-membered rings. After a start with saturated polyesters of simple glycols, e.g., ethylene-, diethylene, propyleneglycol, etc. and saturated dibasic acids, e.g., succinic, adipic, sebacic acid, interest has now turned to condensates containing also ethylenically unsaturated glycols, dibasic acids or anhydrides, in particular maleic anhydride and fumaric acid. Cross-linking based on functional groups other than double bonds, with the exception of epoxy groups, will be mentioned only briefly.

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It was further found that an advantageous handling of polyesters results from a two-stage reaction, i.e., a separation of condensation and polymerization in which the unsaturation leading to the final "set" does not participate in the first-stage reaction, and where the polyester prepolymers prepared during the first stage are of such low or medium molecular weight that they are liquid or easily melted and can be hardened *in situ* during the second stage. If more than two-functional acids or alcohols are used, the cross-linking of which would unnecessarily complicate the first-stage reaction, their amounts are restricted to such quantities that the gel point is not reached at the conversions reached prior to the final cure.

As for the amount of unsaturation necessary for gelation, any amount in excess of one double bond per molecule will result in a change from soluble thermoplastic to insoluble thermoset resin. The degree of cross-linking depends of course on the increase in unsaturation, based frequently upon studies of the homo- and copolymerizations of styrene and divinyl benzene (*2, 3, 4*). The progress of the first-stage condensation can be followed by such conventional methods as (COOH)- group titration, cryoscopy, or viscometry (*5, 6*).

Typical resin compositions include (1) polyester, (2) monomer, (3) catalyst, (4) inhibitor. By (1) we refer to the first-stage polyester condensation products described above. As to (2), up to 1939, cross-linking in maleic alkyds was effected without the use of vinyl monomers. Because the double bond in conjunction with a carbonyl group can undergo copolymerization with vinyl derivatives, syntheses were soon attempted with the thought that the resulting polymers would combine the properties of alkyds and vinyls. Instead, a new kind of synthetic resin was obtained. Many vinyl, acrylic, allyl, and even diene compounds have since been successfully used, e.g., styrene, vinyl acetate, methyl methacrylate, and diallyl phthalate to name but a few (*5, 7, 8*). The amount of cure affected by these compounds can be followed in a number of ways (*9, 10*). (3) The catalysts employed are usually organic peroxides, although ionic initiation, e.g., with $SnCl_2$, the ferrous salt of diethyleneglycolmono-maleate, etc. (*11*), and radiation (*12*), are also used to promote cure. Reaction promoters, or "activators," are also more and more employed, such as ammonia, amines, alkaline earth carbonates, alkyl mercaptans, and hydrazines (*13–18*). These promoters frequently are redox systems or electron donor-acceptor pairs which enhance the fission of the catalyst into radicals by electron donation. This permits the formation of one radical and one ion which later reverts

$$RO{:}OR + {:}X \rightarrow RO^- + RO\cdot + \cdot X^+$$

$$RO^- + Y \rightarrow RO\cdot + Y\cdot^-$$

$$Y\cdot^- + \cdot X^+ \rightarrow X{:}Y$$

to an ordinary radical by returning its extra electron. By suitably varying catalyst, activator, and reactant concentrations, cure times from several hours at 110°C to $^1/_2$ hr. or less at room temperature, may be obtained (*19*). (4) Inhibitors for polyester systems increase the shelf life of uncatalyzed and catalyzed mixtures, as well as the "pot life" of mixtures being processed. This must be achieved without interfering with subsequent polymerization or adversely affecting the physical properties of the final product. Many compounds have been claimed as inhibitors of varying degrees of efficiency, among them (*9*): inorganics (e.g., S, Cu, nitrates); polyhydroxy-aromatics (e.g., hydroquinone ((HQ)), catechol, *t*-butyl catechol ((TBC)), pyrogallol); quinones (exception: anthraquinone); and amines (e.g., *p*-phenyl naphthylamine, pyridine). The action of some of these compounds will be discussed below.

Factors affecting the rate of conversion from the unsaturated to the final cured resin are numerous. Among these are: molecular weight of the glycol acid prepolymer; type and proportion of catalyst; ratio of vinyl derivative to glycol acid; and the nature of the inhibitor. Three reactions are competing: additional homopolymerization of the prepolymer, copolymerization, and homopolymerization of the monomer. Final properties are determined by the predominant reaction of the three which depends, in turn, on reaction constants, temperatures, and concentrations.

The remainder of this paper will be concerned with the results of studies varying individual parameters in resin synthesis. By this approach it is hoped that the possibilities offered in the field of the unsaturated polyesters will be best demonstrated.

COMPATIBILITY

If reactivity were the only factor, "curing" of an unsaturated polyester could be carried out with any unsaturated compound, i.e., vinyl, allylic, etc., capable of reacting with the original double bonds. However, equally to be considered are the mutual solubilities of the components of an uncured polyester mixture, and "compatibility" can often be used to predict the success of the cure. Table I shows one example, where transparency is used as a measure of successful copolymerization, and thus cure. Frequently, solubility limitations may be overcome by raising the temperature, by addition of mutual plasticizers or solvents, or by modifying one or the other constituent. In many cases, however, the monomer by itself is reasonably well compatible with unsaturated polyesters, especially if the latter are not of high molecular weight.

Table I. Polyester Composition versus Clarity

Diethylene glycol-maleate, %	*Vinyl acetate, %*	*Transparency*
95	5	Clear
68	32	Clear
65	35	Turbid
60	40	Cloudy
50	50	Opaque
25	75	Opaque, nonhomogeneous
10	90	Opaque, granular
5	95	Complete incompatibility

A low molecular weight is also usually desirable for a better wetting of filler or a good fiber impregnation, and can be afforded without introducing appreciable disadvantages to the resultant strength because the latter is determined by the success of the cure, rather than by the chain length of the pre-polymer. The limitation of polyester molecular weight is achieved by introducing a percentage of mono-functional acids or alcohols, or alternatively an excess of difunctional component, calculated to give the desired chain length. The molecular proportion of monomer to polyester unsaturation has also to be controlled since many polymers resulting from the homopolymerization of excess monomer are not compatible with the polyester.

Polymerization compositions are simplified by the fact that maleic and fumaric esters do not polymerize by themselves. A 1:1 molecular ratio of vinyl- or allyl- to polyester-unsaturation therefore assures tight copolymerization across the polyester chains. On the other hand, in a polyester cured for example with styrene, additional styrene can be incorporated and will render the resin more styrenelike. Thirty to fifty per cent styrene are as a rule tolerated, i.e., will give clear resins depending on the type of polyester, but up to 90% can sometimes be incorporated if clarity is not required.

Apart from being a sign of compatibility, water-whiteness of the product is often an object itself. Purity of reactants is of prime importance here. Even using carefully purified and compatible materials, however, some haze can often be found in cured polyesters, presumably resulting from some crystallization or density fluctuations. The sodium salt of duodecylbenzene (*20*) has been recommended to overcome this

Table II. Polyesters Containing the *p*-Phenylene Linkage

No.	Repeating unit	No. of chain atoms between p-phenylene linkages	Crystallite melting point, °C.	Crystallinity
1	—$CH_2O \cdot CO$⟨⬡⟩$CO \cdot O \cdot CH_2$—	6	265	Yes
2	—$CH_2O \cdot CO \cdot CH$(—CH_2—CH_2—)$CH \cdot CO \cdot O \cdot CH_2$—	6	. . .	No
3	—$CH_2 \cdot CH_2O \cdot CO$⟨⬡⟩$CO \cdot O \cdot CH_2$—	7	235	Yes
4	—$CH_2CH_2O \cdot CO$⟨⬡⟩$CO \cdot O \cdot CH_2 \cdot CH_2$—	8	230	Yes
5	—$CH_2CH_2CH_2 \cdot O \cdot CO$⟨⬡⟩$CO \cdot O \cdot CH_2CH_2CH_2$—	10	155	Yes
6	—$CH_2O \cdot CO$⟨⬡⟩$\cdot O \cdot (CH_2)_4 \cdot O \cdot$⟨⬡⟩$CO \cdot O \cdot CH_2$—	6	252	Yes
7	—$CH_2O \cdot CO$⟨⬡⟩$CH_2CO \cdot O \cdot CH_2$—	7	. . .	No
8	—$CH_2O \cdot CO \cdot CH_2$⟨⬡⟩$CH_2CO \cdot O \cdot CH_2$—	8	137	Yes
9	—CO⟨⬡⟩$O \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot O$—	6	185	Yes
10	—$CO \cdot CH_2$⟨⬡⟩$O \cdot CH_2 \cdot CH_2 \cdot O$	6	172	Yes
11	—$CH_2 \cdot CO \cdot O$⟨⬡⟩$O \cdot CO \cdot CH_2$—	6	ca. 300	Yes

haze and probably acts by collecting on, and masking, internal interfaces.

NATURE OF THE PRE-POLYESTER

Whereas the classical alkyd resin was mainly composed of *o*-phthalic anhydride and glycerol, more recent polyesters belong to the group of linear, unbranched chains and may be represented by the structure AGAGAGAG, where A refers to terephthalic, succinic, adipic, maleic, itaconic, etc., acids, and G refers to any of the series of *n*-methylenic-, ethylene oxide-, propylene oxide-, etc., glycols. The use of *o*-phthalic acid is limited since the resulting kinking reduces the crystallinity and thus many desirable properties of the cured resin.

Qualitatively, it is clear that stiff units like terephthalic and fumaric acid residues or ethylene glycol will produce harder more heat-resistant resins than units containing sebacic acid or polyoxyethylene glycols. A quantitative approach to this problem has been provided by the work of Hill and co-workers and the theories of Flory (*21*, *22*).

Tables II and III and Fig. 1 illustrate the magnitude of the stiffening influence of the *p*-phenylenic unit, the plasticizing effects of successions of ethylene groups, and the importance of regularity for the proper deployment of molecular forces leading to crystallization.

Of greatest importance further with respect to the mechanical properties is the confirmation of Flory's theory of copolymer crystallization (*23*), according to which it is the mol-, and not the weight-fraction of components which determines melting characteristics. An illustration of this point is given in Fig. 2, which demonstrates this fact for ethylene terephthalate copolymers. It is thus possible, by careful selection of component molecules, to retain thermal stability while increasing resin flexibility and toughness, a combination normally difficult to achieve.

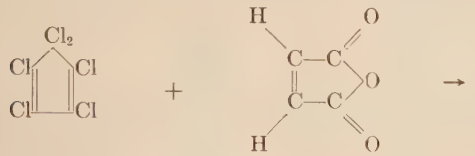
Maleic anhydride and fumaric acid residues are, because of their availability and cheapness, the most common sources of unsaturation in the polyester chain, but aconitic and itaconic acid are also often used. Though fumaric acid reacts

Table III. Some Examples of the Effect of the *p*-Phenylene Linkage in High Polymers

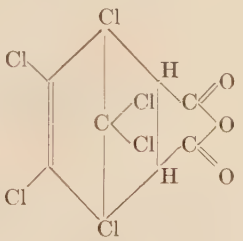
No.	Repeating unit	Melting point, °C.	Crystallinity, solubility
1	—$CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2$—	135	Highly cryst. Soluble in hot toluene and xylene
2	—CH_2⟨⬡⟩CH_2—	380	Highly cryst. Insoluble except in very high boiling solvents
3	—$CH_2O \cdot CO \cdot (CH_2)_4 \cdot CO \cdot O \cdot CH_2$—	50	Highly cryst. Readily soluble in chloroform and acetone
4	—$CH_2O \cdot CO$⟨⬡⟩$CO \cdot O \cdot CH_2$—	264	Soluble only in phenols, or high boiling solvents
5	—$(CH_2)_3 \cdot NH \cdot CO \cdot (CH_2)_4 \cdot CO \cdot NH \cdot (CH_2)_3$—	264	Soluble only in highly polar solvents
6	—$(CH_2)_3 \cdot NH \cdot CO$⟨⬡⟩$CO \cdot NH \cdot (CH_2)_3$—	>400	Highly cryst. and insoluble
7	—$(CH_2)_4CO \cdot NH \cdot (CH_2)_8NH \cdot CO \cdot (CH_2)_4$—	197	Crystalline
8	—$(CH_2)_4CO \cdot NH \cdot CH_2 \cdot CH_2$⟨⬡⟩$CH_2 \cdot CH_2 \cdot NH \cdot CO(CH_2)_4$	285	. . . . .
9	—$CO \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CO \cdot O$—	85° (98°)	Microcrystalline powder
10	—CO⟨⬡⟩$CO \cdot O$—	>300	Crystalline

more slowly than maleic, it produces harder and more heat-resistant resins. Itaconic acid provides an additional range of resins because of easier copolymerization with many monomers. An extremely wide field lies in the use of Diels-Alder adducts with conjugated systems, thus permitting introduction of unsaturated succinic acid derivatives and of cyclic unsaturated diacids. Unsaturation can be still further varied by simultaneous incorporation of different saturated and unsaturated acids and by terminating the pre-polyester chains with vinyl or allyl groups, or mono- or di-olefinic fatty acids. The higher the degree of unsaturation, the harder and more solvent-resistant the copolymerized polyester resin becomes. Table IV, for example, presents some recent data on the effect on softening points and mechanical properties of replacing phthalic by fumaric acid.

An interesting special use of a Diels-Alder adduct for achieving flame resistance has recently been found (*24*) in the incorporation of chlorendic acid (or HET—acid of the Hooker Chem. Co.) formed from hexachlorocyclopentadiene and maleic anhydride through the cyclic anhydride intermediate:



hexachlorocyclopentadiene + maleic anhydride →



chlorendic acid anhydride

Chlorendic acid is easily esterified with dihydric alcohols to form linear polyesters, stable to further peroxide-initiated polymerization at the double bond either alone or in the presence of styrene. Since the sequence GCGCG, where G refers to glycol units and C refers to chlorendic acid, is thus unreactive to cross-linking agents, G-C-G-M-G-C-G sequences with maleic acid centers of unsaturation must be provided if cures are to be effected. Chlorendic acid resins, particularly in the presence of small amounts of antimony oxide, have higher strength, lower susceptibility to degradation at high temperatures, greater resistance to ignition and slower burning rates than comparable tetrachlorophthalic resins (see Fig. 3). The value of such properties for impregnating cellulosic fibers is obvious.

ADDITIONAL MEANS OF CURING

Aside from styrene which is widely used because of availability and effectiveness, other common monomers have been widely applied. Diallyl phthalate produces resins of greater abrasion resistance; acrylonitrile yields laminates of great flexural strength and excellent chemical resistance; triallyl cyanurate yields greatly improved heat resistance, withstanding as much as 200 hr. at 400°F. (see Table V). This resistance is of great importance for glass fiber laminates and, in conjunction with chlorendic acid, also for wood and paper. Combinations of triallyl cyanurate with diethylene glycol bis allyl carbonate have also produced resins of excellent strength and heat resistance.

Styrene can be further cross-linked with divinyl benzene. A series of resins of widely varying rigidity can be obtained with the system fumaric–phthalic–sebacic–propyleneglycol + styrene–divinylbenzene.

Linking polyester unsaturation by means of vinyl or allyl

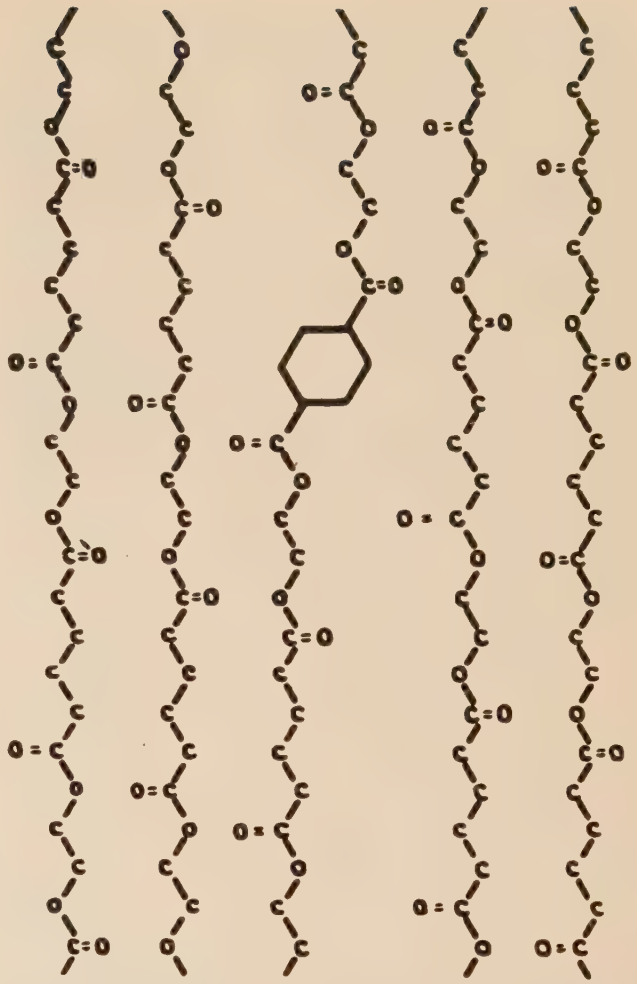


Fig. 1. Disturbance in the chain packing of polyethylene adipate/terephthalate by a single p-phenylene linkage

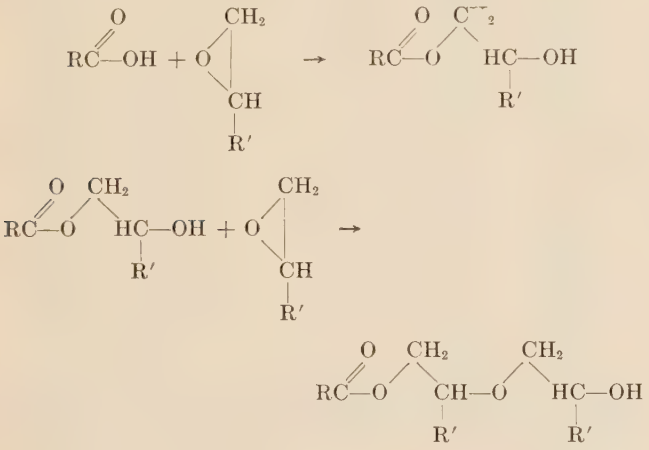
Table IV. 70 Parts Propylene Fumarate (10–1) Phthalate (0–9) 30 Parts Styrene

Mol % fumaric	*Mol % phthalic*	*Exotherm, °F.*	*Flexural strength, p.s.i.*	*Modulus in flexure × 10⁵*	*Tensile strength, p.s.i.*	*Modulus in tension, × 10⁵*	*Elongation, %*	*Heat distortion, °C.*	*Water absorption, 24 hr. at 77°F. %*
100	0	444	13,100	5.5	4200	6.4	0.43	146	0.58
90	10	436	13,700	5.6	5800	...	0.63	135	0.42
80	20	433	14,600	5.7	6500	8.7	0.93	125	0.35
70	30	424	16,000	6.0	6800	9.3	1.01	118	0.28
60	40	410	17,600	6.2	8000	9.6	1.3	109	0.27
50	50	390	17,900	6.5	6900	...	1.25	94	0.20
40	60	356	14,100	5.5	6100	8.7	1.15	79	0.19
30	70	300	13,400	5.2	5600	8.3	1.07	62	0.18
20	80	229	13,000	5.1	5200	7.2	0.89	53	0.12
10	90	200	...	...	...	...	...	...	...

polymerization is not the only way of curing polyesters to three-dimensional networks. Any type of reactive group left in the process of primary ester formation is a suitable avenue for later cross-linking. The manner in which the remaining groups are introduced is relatively simple, at least in theory. Using a slight excess of either acid or glycol in prepolymer formation will result in either acidic or hydroxyl end groups. These are then tied by 3- or 4-functional acids, esters, alcohols, amines, etc. With so few reactive centers per molecule cross-linking is slow unless a very reactive cross-linking agent is used such as the diisocyanates, which find wide use in Vulcollan polyesters.

Cross-link density and reaction speed can also be increased by introducing higher functional untis into the pre-polyester, and then using a percentage of chain terminators which will permit branching, but not cross-linking. At the end of these branches, additional (OH) and (COOH) groups will then be located. NH_2-groups are not commonly introduced, since their much higher reactivity results in premature cures.

At this point epoxy compounds, which react easily with excess acid groups or anhydrides and form cross-links of the polyester-polyether type, might be mentioned.



In such epoxy reactions theoretically nothing is split off, and only a small volume contraction results. Small amounts of water split off by some side esterification reactions can be taken up by other epoxy groups or by acid anhydride. The reaction can be greatly accelerated by small amounts of amines.

INHIBITION

Although many studies have been reported on the inhibition of both the thermal and catalyzed polymerization of styrene and other vinyl monomers (*25*), little work is reported in the field of unsaturated polyesters. This is unfortunate since polymerization of stored catalyzed polyester-vinyl mixtures constitutes a serious problem, appreciably shortening the shelf life of many polyester resins. Cass (*9*), studying room temperature cures of polyester systems inhibited by quinone (Q), hydroquinone (HQ), and *t*-butyl catechol (TBC), and Burnett (*26*), studying essentially the same systems at higher temperatures, found the relative inhibitor effectiveness to be in the order of Q > HQ > TBC.

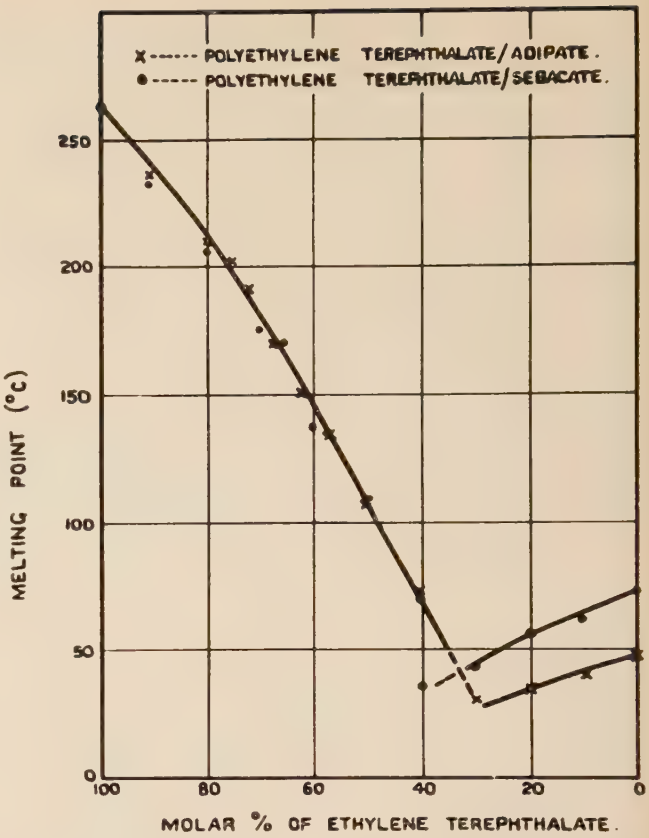


Fig. 2. Melting point versus composition for polyethylene terephthalate copolymers

Of added significance were their observations that HQ and TBC acted as polymerization activators in certain systems. Figure 4 strikingly demonstrates the comparative inhibition of HQ versus Q in the system diethyleneglycol maleate–diallyl phthalate (DEGM-DAP).

Table VI. Comparative Inhibition by Q and TBC

Sample	*Inhibitor (% by weight) TBC*	*Q*	*Shelf life, days*
A	0.01	..	9–13
B	0.01	0.01	24–29
C	..	0.01	32–33
D	..	0.05	57–59

Polyester: DEGM-DAP((1:1)), 0.8% *t*-butyl perbenzoate, 25–28°C.

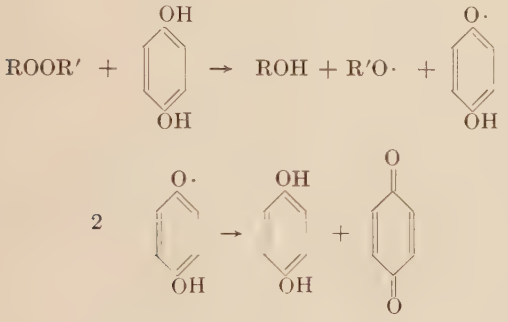
Table V. Heat Aging of Glass Cloth Laminates Involving a Modified Maleic Alkyd and Various Monomers

Monomer	*Glass cloth 181-*	*Resin content, %*	*Laminate no.*	*Flexural strength × 10^{-3} (room temp.)*	*Flexural strength × 10^{-3} 260° after aging at 260°*		
					3 hr.	*24 hr.*	*192 hr.*
Styrene	114	29	1	63.3	...	17.5	2.6
DAP	114	28	2	51.5	...	9.5	0.0
TAC	114	37	3	43.2	...	27.1	15.6
TAC	136	33	4	58.9	32.0	36.3	18.9
CAC	114	42	5	38.9	11.1	0.0	...
TAA	114	35	6	35.5	18.7	15.4	0.0
TAA	136	38	7	60.0	19.5	24.3	0.0
TC	114	32	8	38.6	22.7	19.4	0.0
VP	136	34	9	40.3	5.0	5.0	0.0
A	114	31	10	82.3	13.7	24.6	0.0

DAP = diallyl phthalate, TAC = triallyl cyanurate, CAC = β-chloroallyl cyanurate.
TAA = triallyl aconitate, VP = 2-vinylpyridine, A = acrylonitrile.

The activating effect of TBC versus Q-inhibition is illustrated in Table VI. In particular it should be noted that sample B, with a 1:1 proportion of the two inhibitors and a total inhibitor concentration twice that of sample C, has an appreciably sorter shelf life.

This activation effect is rather unexpected and the details of the process in view of the complexity of the mechanism of inhibition by quinone alone, are undoubtedly very involved (*27, 28, 29*). The greater effectiveness of quinones compared with polyhydric phenols had been previously established (*30, 31*). In fact, HQ is not an inhibitor for the thermal polymerization of styrene in the absence of oxygen (*32*), so that conversion to corresponding quinones in the presence of oxygen or peroxides is believed to account for the inhibition observed. That peroxides in the presence of oxygen cause the transformation of HQ to Q had been demonstrated by Cass (*33*) in preliminary kinetic experiments. The acceleration of polymerization proceeds most likely by a "reduction-activation," where the mechanism of reduction of the peroxide involves the occurrence of free radicals which initiate the polymerization:



It follows that quinones are the preferred inhibitors, capable of extending shelf life practically indefinitely, yet removed in actual use by sufficient catalyst.

CONCLUSION

Research into many other aspects of polyester chemistry (adhesion, metal-sealing, filler utilization, laminations, etc.) is now in progress. Considering the possible number of resins using chemicals available either now or in the foreseeable future, the domain of the unsaturated polyester shows unlimited scope and promise.

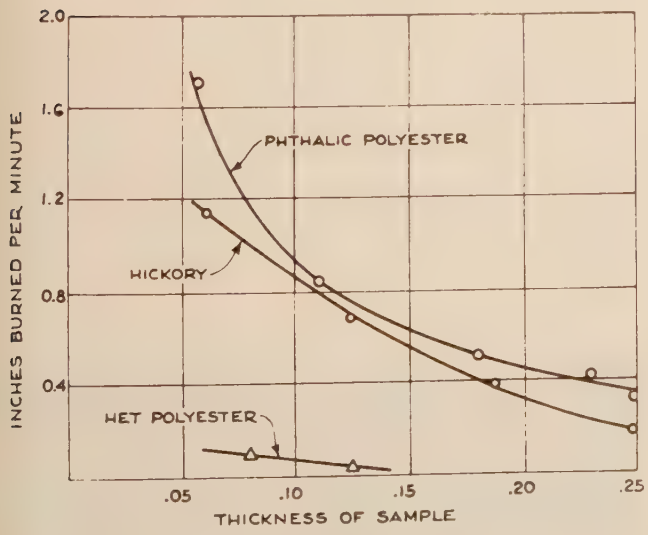


Fig. 3. Burning rate versus thickness method of ASTM D 757-49

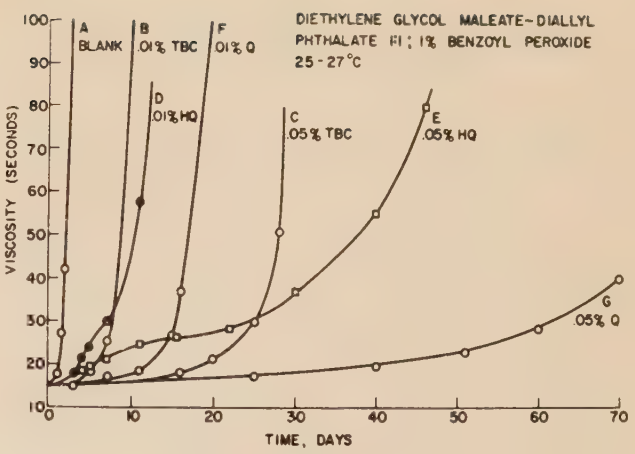


Fig. 4. t-Butyl catechol, hydroquinone, and quinone as inhibitors

LITERATURE CITED

1. Carothers, W. H., and Hill, J. W., *J. Am. Chem. Soc.* 54: 1579 (1932).
2. Dykstra, H. L., U. S. pat. 1,945,307 (1934).
3. Lespilan, R., and Deluchat, *Compt. rend.* 190: 683 (1930).
4. Staudinger, H., *et al., Trans. Far. Soc.* 32: 323 (1936).
5. Rust, J. B., *Ind. Eng. Chem.* 32: 64 (1940).
6. Chelnokova, G. N., *et al., Izvest. Akad. Nauk U.S.S.R. Otdel. Khim Nauk*, 205 (1949).
7. Kropa, E. L., and Bradley, T. F., *Ind. Eng. Chem.* 31: 1512 (1939).
8. Britton, E. C., *et al.*, U. S. pat. 2,285,562 (1942).
9. Cass, W. E., Division of Paint, Varnish, and Plastics Chemistry, American Chemical Society, papers presented at Chicago meeting (Sept., 1953).
10. Fineman, M. W., and Puddington, I. E., *Can. J. Research*, 25B: 101 (1947).
11. Harris, R. R., British pat. 596,190 (1947).
12. Jones, J. L., U. S. pat. appl. 723,449, *Official Gazette* 636: 366 (1950).
13. Kropa, E. L., U. S. pat. 2,472,801 (1949).
14. Biggs, B. S., U. S. pat. 2,448,572 (1948).
15. Frilbette, V. G., U. S. pat. 2,568,331 (1951).
16. Hurdis, E. C., U. S. pat. 2,449,229 (1948).
17. Opp, C. J., and Werner, R. E., U. S. pat. 2,574,753 (1951).
18. Hoover, W. R., and Paulsen, R. M., U. S. pat. 2,428,788 (1947).
19. Parker, E. E., and Moffett, E. W., Division of Paint, Varnish, and Plastics Chemistry, American Chemical Society, papers presented at Chicago meeting (Sept., 1953).
20. Frazer, G. G., and Park, W. F., U. S. pat. 2,577,414 (1951).
21. Edgar, O. B., and Hill, R., *J. Poly. Sci.* 8: 1 (1952).
22. Flory, P. J., Mandelkern, L., and Hall, H. R., *J. Am. Chem. Soc.* 73: 2532 (1951).
23. Flory, P. J., *J. Chem. Phys.* 17: 223 (1949). Evans, R. D., Mighton, H. R., and Flory, P. J., *J. Am. Chem. Soc.* 72: 2018 (1950).
24. Robitschek, P., and Bean, C. T., *loc. cit.* (1951).
25. Bovey, F. A., and Kolthoff, I. M., *Chem. Revs.* 42: 491 (1948).
26. Burnett, R. E., Division of Paint, Varnish, and Plastics Chemistry, American Chemical Society, papers presented at Chicago meeting (Sept., 1953).
27. Cohen, S. G., *J. Poly. Sci.* 2: 511 (1947).
28. Bartlett, P. D., *et al., Disc. Far. Soc.* 2: 342 (1947).
29. Mayo, F. R., and Gregg, R. A., *J. Am. Chem. Soc.* 70: 1284 (1948).
30. Foord, S. G., *J. Chem. Soc.* 48 (1940).
31. Cohen, S. G., *J. Am. Chem. Soc.* 69: 1057 (1947).
32. Breitenbach, J. W., *et al., Ber.* 71B: 1438 (1938).
33. Cass, W. E., unpublished paper.

CHAIRMAN MARK: We will proceed to our last lecture which deals with a different kind of compound which is not very old, therefore, many of its properties are just being explored. We are very fortunate to have Mr. Kaufman, who has worked in the polymer field for a long time and who has worked in the fluorine field for several years, as our speaker. Mr. Kaufman of the M. W. Kellogg Co.!

Modified Polymers Containing Fluorine

H. S. KAUFMAN

THE various projects associated with atomic bomb research during World War II resulted in numerous developments which are gradually being disclosed for general industrial application. Not the least important of these are the fluorocarbons and modified fluorocarbons which proved important because of their stability to the highly reactive fluorine compounds used in the Oak Ridge gaseous diffusion process for the separation of uranium isotopes.

The current interest in these materials arises primarily from their thermal stability and chemical inertness As the title of the paper suggests, our discussion will be limited to high polymers of modified fluorocarbons. Most emphasis will be placed on the homopolymer of monochlorotrifluoroethylene which is commercially available as an M. W. Kellogg product under the registered trade-mark KEL-F and as a bakelite product under the name of Fluorothene or CF3. These materials combine the thermal and chemical stability associated with fluorocarbons with many of the outstanding properties associated with thermoplastic high polymers. From the point of view of the specific field of the pulp and paper industries the combination of these properties offers numerous applications ranging from corrosion resistance and antisticking properties as applied to the manufacturing facilities; to the eventual coating of paper products for chemical resistance.

Before entering into a formal discussion of this special class of high polymers, we may discuss briefly and in general terms the basic reasons for the outstanding chemical and thermal stability of fluorocarbon materials.

The fluorine atom is one of the smallest atoms, only slightly larger than hydrogen, and it is the most electronegative of all elements. The bond energy of a carbon-fluorine bond is extraordinarily high, 107 kcal. per mol. This is almost twice that of any of the other halogen-carbon bonds and about 25% higher than the carbon-hydrogen bond energy. Thus, because the fluorine atom is held very firmly and closely to carbon it resists both chemical and thermal attack. This great stability is actually observed in the pure fluorocarbon polymer of tetrafluoroethylene, commercially available as du Pont Teflon. This material is a waxy crystalline solid having a first order transition temperature (*Tm*) of 327°C. It is completely insoluble and withstands the attack of practically all chemicals except molten alkali metals.

The inherent nonmelt and nonflow characteristics of Teflon make it very suitable for high temperature applications; however, it cannot be molded by conventional thermoplastic techniques.

The extreme properties of Teflon may be modified by substituting a chlorine atom for one of the four fluorine atoms in the monomer. This chlorine modified fluorocarbon is known as polychlorotrifluoroethylene. The high molecular weight resins are colorless, crystallizable plastic solids with a first order transition of 212°C.

PROPERTIES OF CHLOROTRIFLUOROETHYLENE

Structure

On the basis of chemical evidence the structure of the polymer is considered to be based on head to tail polymerization of the monomer.

An x-ray investigation of the structure of KEL-F was undertaken (*3*) in order to obtain an understanding of the behavior of the polymer in terms of its structural parameters. The unit cell dimensions were obtained from measurements of highly oriented fiber diagrams. The cell was found to be hexagonal with the dimensions A = 6.5 A and C = 35 A (Fig. 1).

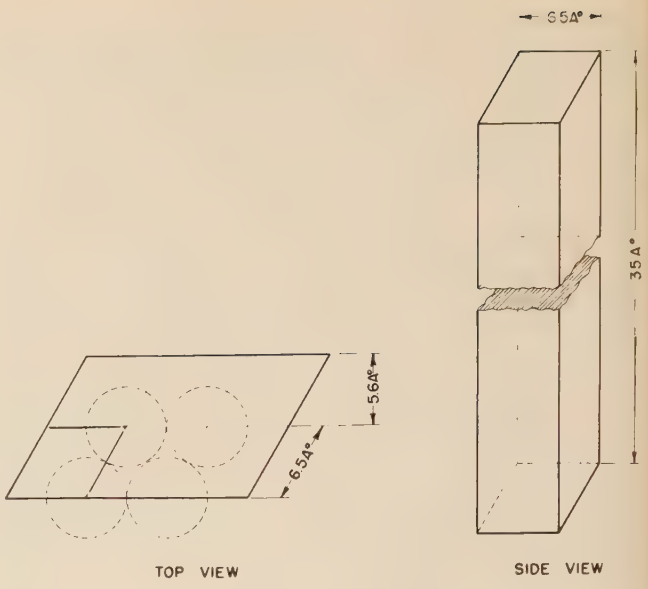


Fig. 1. Hexagonal unit cell KEL-F polymer

One structure which accounts for the extraordinarily long fiber spacing of 35 A is a helical chain arranged so that the helix repeats itself every 14 monomer units (Fig. 2). This structure is similar to that assigned to the helix of polyisobutylene (*1*) and of Teflon (*6*). A planar zig-zag structure such as that of polyvinylchloride is ruled out because it requires a fiber axis spacing of about 5 A.

On the basis of this assumed structure, the density of the polymer may be calculated using the equation:

$$d = \frac{1.65 \times M \times N}{V}$$

where

M = molecular weight of monomer unit = 116.5
N = number of monomer units per unit cell = 14
V = volume of unit cell = 1290 A

The calculated value is 2.10 grams per cc., in agreement with the value of 2.12 grams per cc. determined experimentally by the flotation method.

The spiral structure suggests ease of crystallization and orientation. Molecular models made to scale show considerable hindrance to rotation and indicate a relatively stiff molecule.

Molecular Weight Grades

The high polymer may be classified according to molecular weight by a number of techniques.

The most common empirical procedure for grading this polymer is the no strength temperature (NST). This test involves the measurement of the temperature required to break a notch sample of polymer under a constant load. The higher molecular weight plastic usually has an NST of 300°C. or higher while lower molecular weight plastic has an NST of about 240°C. A new modification of this test

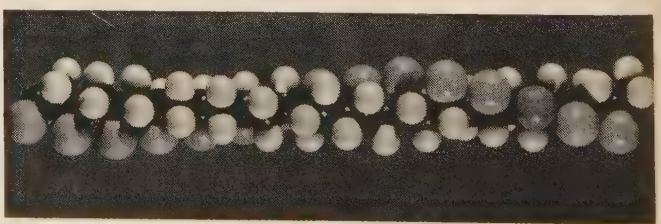


Fig. 2. Structural model of KEL-F polymer

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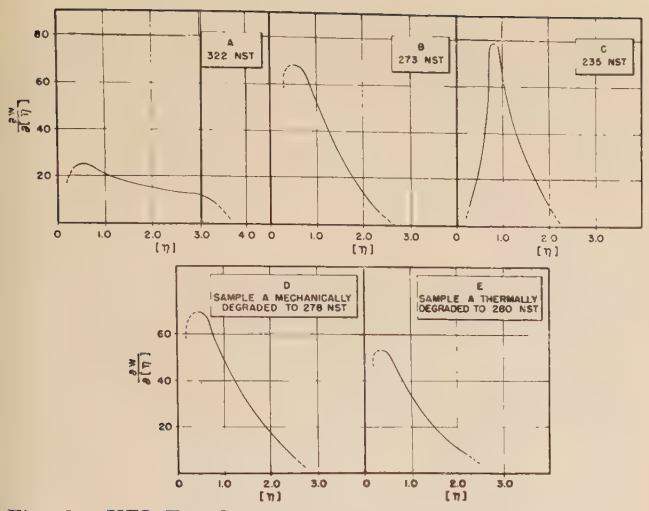

Fig. 3. KEL-F polymer differential distribution curves

which is simpler and more rapid, is called the zero strength time (ZST).* In the latter test, the temperature and load are constant and the time to break is measured. Both of these tests are related to molecular weight in that they are a measure of melt viscosity, the latter being a function of molecular weight.

Another test method that is being used for grading this polymer is the melt flow index. This makes use of an extrusion plastometer and depends upon the varying amounts of polymer extruded under standard conditions in a given time.

Solution viscosities are also employed for grading these polymers. One difficulty encountered in all solution measurements is the room temperature insolubility of the polymer. Dilute solution properties must be measured in uncommon liquids such as 1,1,3-trifluoropentachloropropane or 2,5-dichlorobenzotrifluoride, at temperatures of 100°C. or higher were specialized apparatus and techniques are required. Basic molecular weight measurements have been obtained with a high temperature osmotic pressure method (*4*) and by high temperature light scattering (*2*). According to osmotic data, the number average molecular weight of the lower molecular weight, 240 NST plastic is about 55,000 to 60,000; according to light scattering data a sample of this grade has a weight average molecular weight of about 350,000. This discrepancy arises in part from the different averages observed by the two methods (number average — Mn versus weight average — Mw) and from the fairly broad distribution curves noted in these materials.

The constants of the Mark equation $[N] = KM^{\alpha}$, have been tentatively evaluated in 2,5 dichlorobenzotrifluoride solutions of KEL-F polymer as

$$K = 2 \times 10^{-5}$$
$$\alpha = 1.0$$

The relatively high value of α indicates a rather stiff chain which is in qualitative agreement with the x-ray data.

A fractionation procedure applicable to this polymer system has been developed (*5*). The apparatus employed was arranged so that all of the necessary manipulations could be carried out at the operating temperature of 150°C.

Fractionations were carried out on a sample from each of the three commercial grades of KEL-F polymer and also on high molecular weight samples which had been degraded mechanically by ball milling and thermally by heating in an oven at 275°C.

Three grams of polymer were required for each fractionation and six to nine fractions isolated with a recovery of at least 95%. The fractions were characterized by intrinsic viscosity measurements in a dilution viscometer especially designed for high temperature operation.

* Trademark for the Kellogg ZST tester with which the test is conducted.

Differential distribution curves (Fig. 3) for these samples show an increasing breadth of distribution as the average molecular weight (or NST) increase. The degraded samples show almost identical distributions which are very similar to the distribution of the medium molecular weight sample. It is inferred from these data that degradation occurs not by a "zipper" mechanism but by random scission.

Crystallinity

Many of the physical and chemical properties of these resins depend upon their crystallinity. KEL-F resins may well be described as crystallizable but not necessarily crystalline. The degree and kind of crystallinity in a given sample is a function of its thermal history, and it is this variation in crystallinity which gives rise to so many of the interesting properties of the plastic. In industry, it is common to speak of the "quick-quenched" resin as "amorphous" and of the "slow-cooled" resin as "crystalline." At best, these terms are relative since only relatively thin samples can be quenched rapidly and completely enough to inhibit crystal growth. Sheets thicker than $^1/_{16}$ in. are almost always somewhat crystalline in the interior because the poor thermal conductivity of the plastic permits rapid cooling of the outer surfaces only.

"Crystalline" KEL-F is a denser, more opaque material with higher tensile strength, lower elongation, and greater resistance to the penetration of liquids and vapors. The "amorphous" plastic, on the other hand, is less dense, more elastic, optically clear, and tough. For many applications where the latter properties are required, the "amorphous" polymer is preferred.

The development of crysallinity at temperatures below the first order transition at 212°C. has been investigated by x-ray methods. A high resolution Geiger counter spectrometer was used to study the fine structure noted in the strong line occurring at 5.5 A (*3*). Typical spectrometer patterns of this region from samples of varying degrees of crystallinity show marked differences (Fig. 4). The quick quenching to a low temperature of polymer heated above its transition temperature results in a glass-clear sample which gives a low intensity, broad diffraction line characteristic of a relatively amorphous structure. Extensive crystallinity with increasing opacity is developed by lengthening the residence time of the polymer at temperatures between 190°C. and the transition temperature. The increase in crystallinity is accompanied by a splitting of the broad amorphous line into two strong and relatively sharp lines with less intense lines at the side.

The influence of the molecular weight on the development of crystallinity was investigated by studying the effect of the various thermal treatments on samples of molecular weights

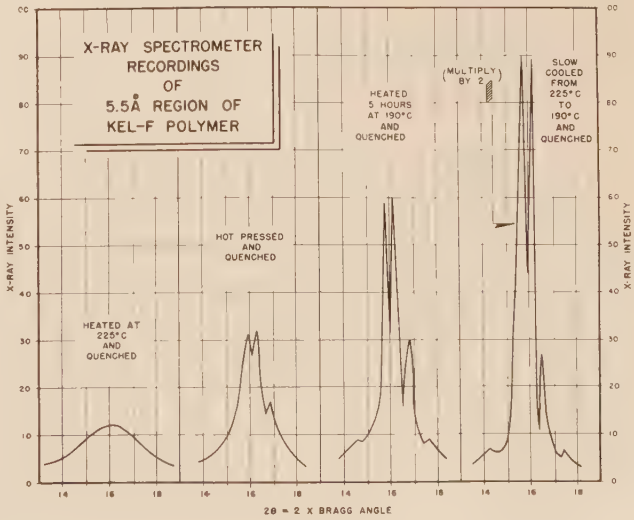
X-RAY SPECTROMETER RECORDINGS OF 5.5Å REGION OF KEL-F POLYMER
HEATED 5 HOURS AT 190°C AND QUENCHED
(MULTIPLY BY 2)
SLOW COOLED FROM 225°C TO 190°C AND QUENCHED
HOT PRESSED AND QUENCHED
HEATED AT 225°C AND QUENCHED
X-RAY INTENSITY
2θ = 2 X BRAGG ANGLE

Fig. 4

of 50,000, 75,000, and 100,000 respectively. For a given heat treatment the degree of crystallinity varied inversely with molecular weight.

General and Mechanical Properties

KEL-F resins are hard and rigid rather than elastomeric. Nonetheless, the elastic modulus of the material varies so little with temperature that thin sections can be flexed without shattering at liquid nitrogen temperatures (−180°C.) and yet retain appreciable strength at temperatures as high as +200°C. The plastic is noteworthy for its strength, toughness, abrasion resistance, good aging characteristics, and flame resistance. There is little difference in mechanical properties between the 240 NST and 300 NST grades although slightly higher moduli are usually observed for the lower molecular weight grade because of its greater tendency to crystallize.

Thermal Properties

KEL-F polymers are noted for their thermal stability at temperatures up to 190°C. KEL-F plastic shows extreme stability when aged for periods up to a year at 150 and 190°C. However, excessively high temperatures tend to degrade the polymer. For example, at 250°C., 300 NST polymer remains above 290 NST after 70 hr., but at 300°C. it drops to 220 NST in 6 hr.

Optical Properties

In thin sections, the quenched resin is colorless and transparent. In thicker sections or when heat-treated, the polymer varies from an opalescent blue to an opaque white depending upon the degree of crystallinity. The resin is highly transparent to high energy infrared radiation.

Chemical Properties

KEL-F resins are noted for their resistance to oxygen, ozone, sunlight, strong acids, bases and including the fuming oxidizing types, and a wide variety of organic solvents. The polymers not only resist chemical degradation by molecular scission but they also resist the penetration of these reagents.

Water vapor transmissions for KEL-F polymers are set forth in Table I in comparison with constants for other plastic film. The permeability of KEL-F plastic is extremely small; only coated cellophane, Saran, and waxed glassine fall in the same class as efficient moisture barriers.

Table I. Water Vapor Permeability Constants

Samples	*Film thickness, mils*	P = *constant* × 10^{-9} [a]
KEL-F (dispersion)	3	3.8
KEL-F (dispersion)	8	0.09
KEL-F (extruded)	3	3.5
KEL-F (pressed)	8	0.07
Cellophane (TAPPI)	1.5	47.0
Pliofilm (TAPPI)	3.2	13.0
Saran	1.0	1.35

[a] P = volume of gas in cu. cm. through 1 mm. thickness/area sq. cm./t (sec.)/cm. Hg differential.

Penetration rates of a number of organic and inorganic liquids and vapors through KEL-F plastic films have been determined by sealing the liquids in bags made from 10-mil KEL-F plastic film and determining the loss in weight as a function of time, Table II. The data point to KEL-F plastic as an excellent packaging material for many organic and inorganic materials.

Electrical Properties

KEL-F resins are of importance to the electrical industry because of their exceptional moisture resistance, chemical and thermal stability, electrical characteristics, and ease of fabrication. Hookup wire insulated with KEL-F is now specified by the Signal Corps for 135 to 150°C. service.

At high frequencies, KEL-F plastic is not as good a dielectric as polyethylene or polystyrene, but it is much better than polyvinylchloride. Of course, polyethylene and polystyrene cannot be used at higher temperatures.

PLASTICIZED CHLOROTRIFLUOROETHYLENE RESINS

For specialized applications, KEL-F resins are plasticized with the low molecular weight chlorotrifluoroethylene oils.

Table II. Permeability—Sealed Bag Tests[a]

Liquids	*Diffusion constants*[b]
Ammonia, 28%	0.02
HCl, 37%	0.02
Benzene	0.02
Methanol	0.02
NaOH, 50%	0.03
Salicylaldehyde	0.04
Bromine	0.10

[a] 10-mil KEL-F film heat sealed. Bags stored 2 weeks at 25°C.
[b] Grams loss per 100 sq. in. per 24 hr. per mil.

Although these oils are among the better solvents for the resin, they are not highly compatible with the resin. The limit of compatibility at room temperature seems to be 25 to 30% oil by weight. In all cases, the plasticized resins are less resistant to chemical attack or reagent penetration, since the oils are readily soluble in many common liquids such as aliphatic and aromatic hydrocarbons and chlorinated compounds. In many applications, e.g., valve diaphragms, the oils are partly leached out and replaced by other liquids. Where this liquid itself serves as a "plasticizer," the diaphragm remains flexible and serviceable.

Fabrication of the plasticized resin is somewhat easier, since the melting temperature (Tm) and melt viscosity of the resin are markedly reduced by the chlorotrifluoroethylene oils.

The plasticizing oils themselves are stable up to 250°C. despite their volatility. They are also inert toward acids, alkalies, and oxidizing agents, and insoluble in water and other polar liquids. The oils also have excellent electrical properties.

METHODS OF FABRICATION

Because KEL-F polymer is a true thermoplastic, it can be fabricated by extrusion, compression, injection, and transfer molding. Coating dispersions can be applied by spraying or dipping.

The high softening point of the resin (212°C.) together with its ability to crystallize or supercool depending on thermal treatment, introduces a number of problems. Rapid quenching tends to produce an amorphous material which is tough and durable. Slow cooling or long heating between 150 to 190°C. tends to produce crystalline material stronger and more chemically resistant than the amorphous form but also less extensible and more brittle.

If carried out properly, compression molding and dispersion fusion do not degrade the resin. Compression molding must be done above the softening point (Tm = 211°C., 410°F.) and is ordinarily accomplished at 250°C. (482°F.) under 500 to 15,000 p.s.i. Molding cycles will depend upon the size and complexity of the item. Metal inserts can be bonded tightly to the plastic. Because the plasticized resin has a lower softening point than the unplasticized resin (Tm for resin with 25% no. 10 plasticizer = 190°C.), molding can be carried out at somewhat lower temperatures. Heat treatment of molded plasticized items, followed by rapid quenching, helps to flux the resin and plasticizer together and to make the items clearer and more homogeneous.

Rod, tubing, wire insulation, and film of KEL-F plastic are fabricated by extrusion. In this case, higher temperatures

plus mechanical working in the screw may lead to some degradation.

Film may be extruded as lay-flat tubing or through a slit die. In the manufacture of lay-flat tubing, the plastic is extruded upward through a circular die, expanded while hot with air pressure, and passed through pinch rolls to the take-up. Since this film is air-quenched, it tends to be somewhat crystalline. In slit extrusion, the film is hot drawn out of the die onto a cold roll which rapidly quenches the plastic.

Injection molding, like extrusion, is accomplished at relatively high temperatures (500 to 550°F. cylinder, 500 to 600°F. nozzle, 300°F. die) which together with mechanical working may lead to some degradation. In injection molding, two opposing factors must be compromised satisfactorily. On the one hand, the molding temperature must be high enough to promote adequate flow and to provide adequate consolidation and impact strength in the molded item. On the other hand, the molding temperature must be as low as possible to minimize degradation. Relatively high pressures, such as 20,000 lb. are ordinarily recommended to permit the use of lower temperatures.

Dispersions

Present-day dispersions are made up to 40% solids, yet they are quite fluid. The dispersions, consisting of finely divided (1 to 10 mu) particles suspended in organic thinners, may be applied by spraying or dipping. With experience, 2 mils or more of the resin can be applied per coat. After each coat, the particles must be fused at 480 to 500°F. for 15 to 30 min. after the item has attained fusion temperature. After the final coat, a 5 to 16-hr. fusion at 480 to 500°F. is recommended for the elimination of porosity. If the coating is to be used primarily for "release" or "antihesive" purposes, a single 1 to 2-mil coating fused for 3 to 5 hr. will suffice. If maximum corrosion resistance is required, a total film thickness of 8 to 10 mils with a final bake of 16 hr. is recommended. For optimum adhesion, surfaces should be degreased and sandblasted before the dispersion is applied.

APPLICATIONS FOR CHLOROTRIFLUOROETHYLENE RESINS

Because of their excellent chemical and thermal stability, electrical properties, zero moisture absorption, and ease of fabrication, KEL-F resins are being used for a variety of industrial, domestic, and military applications.

In the chemical industry, gaskets, diaphragms, packings, linings, and coatings of KEL-F are used wherever excessive corrosion or wide temperature extremes are encountered. In the electrical industry, wire insulated with KEL-F is being manufactured on a large scale for service up to 150°C. Injection molded parts of complex design with and without metal inserts are assuming great importance in electronic equipment with its trend toward miniaturization and higher temperatures. Magnet wire with superior aging properties and moisture resistance can be made by continuous coating with a special grade of dispersion.

In the food industry, thin dispersion coatings are serving as efficient release agents for bread dough, candy, and meat products. In the medical and pharmaceutical fields, the resins are of great value because items such as tubing and film can be sterilized without distortion and even incorporated in the body, apparently without harmful effects. In all these areas, and many others as well, packaging with polychlorotrifluoroethylene film is becoming more and more attractive, since the resin is highly resistant not only to the permeation of moisture but also to the passage of many organic and inorganic liquids and vapors.

LITERATURE CITED

1. Fuller, C. S., Frosch, C. J., and Pope, N. R., *J. Am. Chem. Soc.* 62: 1909 (1940).
2. Hall, H. T., *J. Poly. Sci.* 7: 443 (1952).
3. Kaufman, H. S., *J. Am. Chem. Soc.* 75: 1477–1478 (1953).
4. Kaufman, H. S., and Muthana, M. S., *J. Poly. Sci.* 6: 251 (1951).
5. Kaufman, H. S., and Solomon, E., *Ind. Eng. Chem.* 45: 1779 (1953).
6. Pierce, R. H. H., Bryant, W. M. D., and Whitney, J. F., presented at National ACS Meeting, Buffalo, N. Y., March, 1952.

CHAIRMAN: Thank you very much. This is an excellent study. As you have certainly seen, those polymers are quite complicated. Are there any questions?

MR. MESROBIAN: I wanted to ask Mr. Kaufman about thermal instability of the polymer. Is that relatively bad compared to the other vinyl polymers in solution—say polystyrene?

MR. KAUFMAN: We have carried out a number of measurements of degradation in solution to as high as 250°C. and we have not seen any evidence of degradation. I suppose you are wondering about the effect of oxygen, but it doesn't seem to affect the polymer in this particular case.

MR. MESROBIAN: Bulk polystyrene may withstand temperatures up to 300°C?

MR. KAUFMAN: At temperatures of about 300°C., Kel-F plastic begins to degrade rapidly.

MR. MESROBIAN: I was wondering why you get that. I was wondering if you tried to calculate the change in molecular weight by the number of cuts in molecules—because I know in the termination step you might get a weak spot in the middle of the chain and you might get one cut.

MR. KAUFMAN: That is an interesting observation but we have not made the calculation.

QUESTION: Will the amorphous film crystallize on aging?

MR. KAUFMAN: Yes, if they are maintained at elevated temperatures. The rate of crystallization is not significant below temperatures of 150°C.

As a matter of fact the current Signal Corps wire specifications state that this polymer may be used for high temperature hook-up wire up to temperatures of 150°C. and I have reason to believe we may be able to increase that 15 or 20° because crystallization proceeds at very slow rates below temperatures of 175° and, if you take the added precaution of using high molecular weight materials, then crystallization proceeds at an even slower rate.

MR. MARK: If I may ask a question, inasmuch as it seems that crystallization leads to undesirable properties, can one—for instance, by the use of copolymers in this material, prevent crystallization?

MR. KAUFMAN: Steps are being taken by various groups to prepare copolymers of this particular type—modified fluorine polymers. But this is really in its infancy. There are the normal polymer principles for this system as for other polymer systems. If you add a copolymer to this material, it will decrease the tendency to crystallize. But, I am afraid it is a little early yet to give specific examples because we don't have enough information.

MR. MARK: When I was in Germany I saw them doing industrial fluorine chemistry. They have a modified fluorine containing polymer called Hostaflon on the market and they have one that is not yet on the market. They also have a whole series of copolymers and apparently have made the observation that eventually copolymerization will help in preventing crystallization in an efficient manner. But, as Mr. Kaufman pointed out, it is not very easy to handle those things and it takes time.

QUESTION: By what methods are these polymers prepared?

MR. KAUFMAN: One of the methods—the method that was employed at the SAM laboratories—this work was done as a part of the Manhattan Project—was a low temperature polymerization using a chlorinated peroxide as the catalyst.

Head table—right end—at the Conference luncheon

Head table—left end—at the Conference luncheon

Methods are also available whereby one uses a suspension polymerization receipt. As a matter of fact, I believe the Hostaflon Mr. Mark spoke of is prepared in a water suspension recipe.

MR. MARK: Apparently one needs free radicals. I think one has tried to use HF as an ionic-type catalyst but apparently it doesn't work.

QUESTION: In your comparison of permeabilities you didn't show the same film thickness. I noticed Saran looked well because it was only 1 mil thickness. Could you enlarge on the effectiveness of Saran and this?

MR. KAUFMAN: The only data I have are those obtained at the Brooklyn Polytechnic Institute sometime ago as part of a program to determine and compare the permeabilities. The values you saw were calculated to unit thickness. I am not familiar with the data for Saran at higher thicknesses.

QUESTION: I might comment. I understand about polyethylene but you had 10 and 20 as the range of moisture vapor transmission and, in our experience, that would be ten times too high.

MR. KAUFMAN: The data are not our data. They were published and I won't lay the blame on anybody's doorstep. It may be the methods were different. I am not sure. But, the people who have been interested in using films of this material for packaging purposes have run them side by side in the same type of test. As a matter of fact, one such group is the Bell Telephone Laboratories who have run the materials side by side and they report their data indicate Kel-F films are in the order of 10 to 20 times better for water permeability than polyethylene. I think it is relative depending on the test, how you set up your definitions, etc.

QUESTION: Is that liquid water or water vapor?

MR. KAUFMAN: Water vapor. Actually liquid water tests have been carried out where people have been interested in sealing aqueous solutions into Kel-F plastic bags. For instance, pharmaceuticals have been sealed into a bag of this material and maintained for something of the order of 2 years at constant temperature up to 100° and weights have been taken at regular intervals and there has been found no measurable loss in weight over this period.

QUESTION: In the impregnation of inorganic fabrics is there an effect relating to penetration? It seems KEL-F particles are larger than the spaces between the fibers and in that case penetration would be incomplete.

MR. KAUFMAN: In our application laboratory, we have come up with a method for impregnating glass cloth—and again this is perhaps a little premature but it will not be long before a product will be available which will consist of Kel-F plastic coated glass fabric which can be used much as a wall paper to coat vessels to make them resistant to chemical attack. The Kel-F plastic will be corrosion resistant and the glass fabric will provide the base. This will be put onto the inside of tanks, drums, pipes, etc.

QUESTION: Do you have a water dispersion of Kel-F coming on in the foreseeable future?

MR. KAUFMAN: Not that I know of.

QUESTION: Is it possible to plasticize Kel-F?

MR. KAUFMAN: Kel-F plastics may be plasticized with the lower molecular weight oils and waxes of polychlorotrifluoroethylene. Because Kel-F plastics have a low range of compatibility with other materials, it has to be plasticized with the same type of material and the Kellogg Co. sells plasticized material which has a lower transition temperature and which may be extruded and worked at lower temperatures.

QUESTION: Is there a certain migration of the oils?

MR. KAUFMAN: There is a tendency, depending on the application, for a certain amount of migration. There are new developments in the laboratory stage which are designed to cut down the amount of migration. For instance, I will give you an example of something that has actually occurred where people have been using Kel-F plastic gaskets or diaphragms for valves. Certain corrosive liquids in contact with the plasticized diaphragms have leached out the plasticizer and taken the place of the plasticizer in the structure so the structure has not been harmed in any way. Over a period of time the corrosive liquid has gotten in and replaced the plasticizer without apparent harm to the system. That is one particular case.

QUESTION: I believe you described Kel-F as being nonadherent to most surfaces. Can you make it adhere?

MR. KAUFMAN: Yes, by suitable surface preparation. In carrying out a dispersion coating job when one wants to coat a paddle wheel, or some surface for corrosion resistance, it is necessary to prepare the surface by sand blasting and thoroughly clean it so one gets adhesion of the Kel-F plastic film to the metal surface.

QUESTION: In the case of Teflon?

MR. KAUFMAN: It is quite a job to get adherence. As a matter of fact, in order to put on a Teflon dispersion you have to first pretreat the surface and put on a primer. The primer is not necessary with Kel-F but it is necessary to have a very clean, sand blasted surface.

QUESTION: How about the copolymer in which the fluorine content is very small?

MR. KAUFMAN: To be frank, our interest in this material is to maintain our outstanding properties of fluorocarbons.

QUESTION: I was wondering if there would be any appreciable change.

MR. KAUFMAN: No. I think in this case it is necessary to maintain the fluorine content to keep the fluorocarbon type properties.

QUESTION: What is the present price of Kel-F in thousand pound lots?

MR. KAUFMAN: $12 a pound. Within the next few months there will be a price reduction. I cannot say what the new price will be.

QUESTION: What about the heat-sealing properties of Kel-F?

MR. KAUFMAN: That is something that can be done quite simply and is being done on a more or less routine basis using standard heat sealing machines that are available. The thin films can be heat sealed—not quite as easily as polyethylene because the temperature is a little higher, but most equipment is capable of producing enough kilowatts where it counts to give adequate heat seals.

QUESTION: Is the polymer or monomer inflammable?

MR. KAUFMAN: The polymer is not inflammable and, to the best of my knowledge, the monomers don't impart flammability.

QUESTION: What is the price of the monomer?

MR. KAUFMAN: I don't know. We make our own monomer. As a matter of fact, I don't think it can be bought anywhere as such. I may be wrong.

CHAIRMAN: I think this brings us to the end of our program for the afternoon and all I can add is to thank again the speakers and thank the discussion speakers and thank all of you for attending this meeting.

Developments in the Application of Resins to Paper

MR. NAZZARO: I'd like to welcome you to the second of this series of TAPPI Plastic Conferences. Your chairman for the day is Joseph Pullman of the American Cyanamid Co. and I am sincerely hopeful that you will enjoy this as much as I will. May I introduce Mr. Pullman!

CHAIRMAN PULLMAN: I am glad to welcome you all here this morning. Most of you, who attended the meeting here yesterday heard an exceptional group of papers on the theoretical aspects of some of the latest developments in the resin-plastics field. Today, the section is sponsored by the Subcommittee in Plastics in Paper Converting, and I believe that the papers will have a practical aspect which will be of definite interest to those interested in papermaking as well as converting.

Plastics Conference luncheon

Now, since we are getting a rather late start, I won't say anything further but I'd like to introduce the first speaker, H. S. Bergen of the Monsanto Chemical Co., who will speak to you on the subject of "Plasticizers—Their Use in Paper Coating Resins." I'd just like to add at the conclusion of each paper, we will have a short discussion in which we will welcome questions from the audience. Mr. Bergen!

Plasticizers—Their Use in Paper Coatings Resins

J. R. DARBY and H. S. BERGEN

MODIFICATION of paper products through the use of resin coatings and impregnants constitutes an accelerating means of broadening the utility and markets for paper. Many paper based products currently on the market have been upgraded through the use of coating materials so that they are not readily recognizable as having been derived from paper. Through such property transformations, it has been possible for paper to compete with premium priced, durable products such that additional markets have been penetrated. Further continuation of this trend is of major interest to the paper industry.

Some paper coating resins require no plasticization. Unplasticized resins, such as polyethylene and styrene-butadiene copolymers, are employed in paper coating operations. Styrene-butadiene resin is particularly useful for clay coating of paper to improve surface conditions, and polyethylene is widely used in laminating to paper because of its low moisture vapor transfer, flexibility, and chemical inertness.

Most of the synthetic resins used to modify the properties of paper require plasticizers to render them useful or to impart optimum properties. Such resins as polyvinyl chloride, polyvinylidene chloride, nitrocellulose, cellulose acetate, etc., should be plasticized to have maximum utility.

The plasticized resins are most commonly used in operations off the papermaking machine. They improve scuff resistance, gloss, heat sealing, mechanical strength, grease resistance, moisture resistance, and resistance to dry and liquid products. It has been found that through the selection of the proper type and concentration of plasticizer, a broad range of properties can be obtained. As a result of the wide choice of plasticizers permitted, the problem of proper formulation is of serious concern.

The purpose of this paper is to discuss the properties the various plasticizers impart to the most important resins used in paper coating operations.

RESINS REQUIRING PLASTICIZERS

The selection of resin will depend upon the properties it is to impart, the method of application best suited to the base sheet and coating, and the cost. Table I lists the plasticized resins most commonly used in paper coatings. The thermoplastic resins are valuable because they can be made flexible or rigid, and advantage can be taken of their thermoplasticity for heat sealing. The thermosetting resins are primarily used in those applications where resistance to elevated temperatures is of paramount importance. These are generally the rigid type, and plasticizers serve to improve shock resistance.

Resins may be applied to paper in the form of solvent solutions, as hot-melts, or as dispersions either in the form of a latex or an organosol or plastisol. The water dispersion method is of interest because of freedom from explosive hazards, elimination of solvent cost and odor, as well as the higher solids generally obtainable with these dispersions. The

J. R. DARBY and H. S. BERGEN, Monsanto Chemical Co., St. Louis, Mo.

Table I. Plasticized Resins Used for Paper Coating

A.	Thermoplastic:
	Polyvinyl chloride and copolymers
	Polyvinylidene chloride and copolymers
	Polyvinyl acetate
	Polyvinyl butyral
	Polystyrene
	Cellulose nitrate
	Cellulose acetate
	Ethyl cellulose
	Cellulose acetate-butyrate
	Acrylics
	Polyamides
	Zein and casein
B.	Thermosetting:
	Phenolics
	Melamines
	Ureas
	Polyesters

plastisol method of application is an ingenious method for depositing a dispersion coating with solids contents up to 100%.

APPLICATIONS OF COATED PRODUCTS

The role of the plasticizer in the various resins can be illustrated by selecting several important applications for paper coatings.

Figure 1 illustrates various coated articles employing plasticizers. Table II lists various applications and the essential property of the plasticizer required.

Nontoxic plasticizers approved by the Bureau of Animal Industry (BAI) and the Food and Drug Administration (FDA) which are grease resistant and promote heat sealing, are essential to the success of the plastic coated paper milk container, lard container, and ice cream carton.

Plasticizers with good flexibility, permanence, and nonmigration made possible vinyl coatings on paper for such purposes as shelf paper, decorative wraps, luggage, and book covers.

Solid plasticizers which tend to supercool are the key to delayed tack, heat-sensitive paper label coatings. In this application, many different types of resins may be used, but the plasticizers which are suitable are limited.

Coatings applied to paper-base building materials, such as acoustical tile, wallboard, etc., find wide application because of the flame retardancy imparted by certain type plasticizers.

The excellent electrical and flow characteristics of certain plasticizers make possible the fabrication of post-formed and "punched" laminates used for insulating purposes.

GENERAL PLASTICIZER CHARACTERISTICS

The major requirements for a plasticizer in paper coating resins may be considered on the basis of processing characteristics, permanence, performance, and cost. These properties and factors are schematically shown in Table III.

Compatibility

The first essential requirement of the plasticizer is compatibility with the base resin selected. Table IV lists the plasticizers which are compatible with various paper coating resins. Compatibility means that the plasticizer should effect a homogeneous film without separation by exudation or crystallization. This compatibility must be maintained under all conditions of use including exposure to moisture, humidity, and ultraviolet light.

Table II. Essential Plasticizer Properties for Some Applications

Application	*Essential plasticizer requirement*
Food containers (milk and beverage containers)	Low extraction, nontoxic, odorless, and tasteless
Greaseproof papers	Grease resistance
Shelf paper, luggage covers, book covers, etc.	Flexibility, low volatility, and migration
Paper labels, heat-seal coatings	Solid plasticizer of selected melting point and tendency to supercool
Acoustical tile	Flame resistance
Insulating laminates	Electrical properties and flow characteristics

Table III. Requirements of a Plasticizer for Paper Coatings

COMPATIBILITY		
PROCESSING		
PERFORMANCE	PERMANENCE	COST
Flexibility	Low volatility	
Softness	Light stability	
Tensile and tear strength	Water resistance	
Nonflammability	Grease resistance	
Abrasion resistance	Low migration	
Heat sensitivity	Fungal resistance	
Electrical properties		
Low toxicity		
Color		
Odor		

Processing

It has been found that the plasticizer exercises a profound effect upon the ease of application of various resins to paper. The ease of solvent release is somewhat dependent upon the type of plasticizer used in a solvent system. In dispersion systems the plasticizer affects the temperature at which maximum physical properties develop. The effect of the fusion characteristics of several plasticizers in a plastisol formulation is illustrated in Fig. 2. At a relatively low temperature, a mechanically strong specimen can be developed with Santicizers 160 and 141, while dioctyl phthalate effects a weak mechanical bond and the polymeric plasticizer shows no evidence of fusion. Similarly, with latex systems such as postplasticized styrene emulsions or copolymer vinylidene chloride types, solvation of the plasticizer on the resin is necessary in order to lay down a continuous film. For example, with copolymer vinylidene chloride it requires a minimum amount of the following type plasticizers to form a continuous film:

Santicizer 141	16 PHR
Santicizer B-16	18 PHR
Paraplex G-50	20 PHR

Fig. 1. Various coated articles employing plasticizers

Performance, Permanence, and Cost

These properties of the various plasticizers are listed in Table V.

The properties considered are for those resins with which the given plasticizer is most commonly used.

Phthalates. The phthalates have a wide range of compatibility with the majority of the thermoplastic resins. They constitute the largest tonnage class of plasticizer used today because of their good color and odor, low toxicity, nonnutrient qualities for fungi, resistance to water extraction, and softening and flexibilizing properties. The general availability and low cost of the raw materials for phthalate esters is responsible for their setting the standard for plasticizer prices.

The compatibility table (Table II) shows that the lower molecular weight phthalates are valuable in cellulose acetate and polyvinyl acetate, while the higher molecular weight phthalate esters are most valuable for polyvinyl chloride, cellulose acetate butyrate, and ethyl cellulose. This point is illustrated by the highly favorable performance of di(*n*-octyl-*n*-decyl)phthalate in polyvinyl chloride where it is one of the most valuable plasticizers available because of its excellent balance of flexibilizing properties and low volatility.

Phthalyl Glycollates. The phthalyl glycollates are particularly valuable because of their low toxicity. The lower molecular weight members are excellent plasticizers for cellulose acetate, while being less volatile than the lower molecular

Table IV. Plasticizers Most Useful with Various Paper Coating Resins

	Resin																			
	Thermoplastic															Thermosetting				
	Vinyls				Cellulosics				Miscellaneous											
Plasticizer	*Polyvinyl chloride and copolymers*	*Polyvinyl acetate*	*Polyvinyl butyral*	*Polyvinylidene chloride and copolymers*	*Nitrocellulose*	*Cellulose acetate*	*Cellulose acetate butyrate*	*Ethyl cellulose*	*Acrylics*	*Polystyrene*	*Chlorinated rubber*	*Polyamides and nylon*	*Zein and casein*			*Phenolics*	*Melamines*	*Ureas*	*Polyesters*	
Phthalates																				
Dimethyl		X				X														
Diethyl		X				X														
Dibutyl		X			X		X	X	X							X				
Diphenyl	X	X						X		X										
Dicyclohexyl	X				X															
Santicizer 160* (butyl benzyl)	X	X	X		X				X	X						X			X	
Dioctyl	X				X		X	X		X										
Di(*n*-octyl-*n*-decyl)	X						X	X												
Phthalyl glycollates																				
Santicizer E-15				X		X		X												
Santicizer B-16	X	X	X	X	X			X	X		X	X	X							
Santicizer M-17	X	X				X		X	X											
Phosphates																				
Triethyl						X														
Tributyl					X															
Trioctyl	X				X		X													
Triphenyl		X			X	X	X	X												
Tricresyl	X	X			X		X	X								X				
Santicizer 140	X	X			X		X	X								X			X	
Santicizer 141	X	X		X	X			X		X			X						X	
Sulphonamides																				
Santicizer 1-H		X						X												
Santicizer 3		X			X			X												
Santicizer 8		X			X	X		X				X	X			X				
Santicizer 9		X						X								X	X	X		
Adipates																				
Diisobutyl	X			X																
Dioctyl	X			X			X	X												
Dibutoxyethyl	X		X				X	X												
Sebacates																				
Dibutyl			X				X	X												
Dioctyl	X						X	X												
Polymeric types																				
Paraplex[a] G-50	X																			
Paraplex G-60	X																			
Glyptal[b] 2557	X			X																
Glycol derivatives																				
Flexol[c] 3-GH		X	X																	
Flexol 4-GO	X				X															
Polyethylene glycols													X							
Miscellaneous																				
Castor oil					X			X												
Acetylated castor oil	X[d]							X												
Butyl acetyl ricinoleate	X[d]							X												
Oleic acid													X							
Aroclors* (chlorinated biphenyls)	X	X			X			X		X	X									
Hydrogenated terphenyl (HB-40*)	X[d]							X												
Ortho-nitrobiphenyl (ONB)	X[d]	X			X	X		X		X										
Acetyl tributyl citrate	X																			
Glycerol triacetate						X														

X—Denotes of special utility.
* Reg. trade mark, Monsanto Chemical Co.
[a] Reg. trade mark, Rohm & Haas Co.
[b] Reg. trade mark, General Electric Co.
[c] Reg. trade mark, Union Carbide & Carbon Corp.
[d] Secondary-type plasticizer.

weight phthalates. Butyl phthalyl butyl glycollate (Santicizer B-16) has found extensive use in polyvinyl chloride and polyvinyl acetate which comes in contact with foodstuffs. Santicizer M-17 finds specialized use because of its excellent grease resistance.

Phosphates. The phosphates are the second most important class of chemical plasticizers from the standpoint of tonnage. The lower molecular weight esters are less important than the higher boiling esters, but triethyl phosphate does find utility in cellulose acetate as a flame retardant plasticizer. Trioctyl phosphate is important for the specialty use of imparting outstanding flexibility to resins with which it is compatible. The phosphates are generally used for their over-all favorable plasticization properties, with the added dividend of flame retardancy. The aryl phosphates such as tricresyl phosphate, Santicizer 140 and 141 and triphenyl phosphate are extremely flame retardant. Triphenyl phosphate, Santicizer 141, and Santicizer 140 in conjunction with phthalates offer optimal light stability. Santicizer 141 is unique in that it has been completely approved by the BAI and the FDA for contact with all foodstuffs and yet it, being an alkyl diaryl phosphate, possesses flame retardancy and good flexibilizing properties.

Sulphonamides. The sulphonamides find utility primarily in specialized applications. Santicizer 9 is especially useful in thermosetting resins such as phenolics and melamines for inducing proper flow characteristics. Santicizer 8 is unusual in

Table V. Plasticizer Properties Imparted to Various Paper Coating Resins[a]

	Property																
	Performance										Permanence						
Plasticizer	*Light color*	*Low odor*	*Nontoxic*	*Softening efficiency*	*Film formation or ease of processing*	*Tensile and tear strength*	*Low temp. flexibility*	*Heat sealability or heat sensitivity*	*Electrical properties*	*Flame resistance*	*Low volatility*	*Light and heat stability*	*Water or water vapor resistance*	*Grease resistance*	*Nonmigratory*	*Nonnutrient for fungi*	*Cost*
Phthalates																	
Dimethyl	X	..	..	X	X	X	X	X	..	..	..	X	..	..	X	X	L
Diethyl	X	..	..	..	X	X	X	X	..	..	X	X	..	..	X	X	L
Dibutyl	X	X	A	X	X	X	X	X	X	..	X	X	X	..	X	X	M
Diphenyl	X	..	A	..	..	H	..	H	..	..	X	X	X	..	X	X	H
Dicyclohexyl	X	..	A	..	..	H	..	H	..	..	X	X	X	..	X	X	H
Santicizer 160 (butyl benzyl)	X	..	..	X	H	H	X	X	X	..	X	X	X	X	X	X	L
Dioctyl	X	X	A	X	X	X	X	X	X	..	X	X	X	..	X	X	M
Di(*n*-octyl-*n*-decyl)	X	..	..	H	X	X	H	X	X	..	H	X	X	..	X	X	M
Phthalyl glycollates																	
Santicizer E-15	X	X	X	X	X	X	X	X	..	..	..	X	X	X	X	X	H
Santicizer B-16	X	X	X	X	X	X	X	X	..	..	X	X	X	X	X	X	H
Santicizer M-17	X	X	A	X	X	X	X	X	..	..	..	X	X	X	X	X	H
Phosphates																	
Triethyl	X	..	..	X	X	X	X	X	..	X	..	..	..	..	X	X	M
Tributyl	X	..	..	X	X	X	H	X	..	X	..	..	..	..	..	X	H
Trioctyl	X	..	..	H	..	X	H	X	..	..	X	..	X	..	..	X	H
Triphenyl	X	X	..	..	X	H	..	X	..	X	H	X	X	X	X	X	M
Tricresyl	X	..	..	..	H	X	X	X	X	X	H	..	X	X	X	X	M
Santicizer 140	X	..	..	..	H	H	X	X	..	X	H	X	X	X	X	X	M
Santicizer 141	X	X	X	X	H	H	X	X	..	X	X	X	X	X	..	X	M
Sulphonamides																	
Santicizer 1-H	X	X	A	..	..	H	..	H	..	..	X	..	..	X	X	X	H
Santicizer 3	X	X	..	..	..	H	..	H	..	..	X	..	..	X	X	X	M
Santicizer 8	X	..	..	X	X	X	X	X	..	..	X	..	..	X	X	X	M
Santicizer 9	X	X	..	..	..	H	..	H	..	..	H	X	..	X	X	X	M
Adipates																	
Diisobutyl	X	..	X	H	..	X	H	X	..	..	..	X	..	..	..	X	H
Dioctyl	X	..	..	H	..	X	H	X	..	..	X	X	X	..	..	X	H
Dibutoxyethyl	X	..	..	H	..	X	H	X	..	..	X	X	X	..	..	X	H
Sebacates																	
Dibutyl	X	..	..	H	..	X	H	X	..	..	..	X	X	..	..	..	H
Dioctyl	X	..	..	H	..	X	H	X	..	..	H	X	X	..	..	..	H
Polymeric types																	
Paraplex G-50	..	..	..	..	..	..	..	..	..	..	H	X	X	H	H	..	M
Paraplex G-60	..	..	..	X	..	..	X	..	..	..	H	X	X	H	H	..	M
Glyptal 2557	..	..	..	X	..	..	X	..	..	..	H	X	X	H	H	..	M
Glycol derivatives																	
Flexol 3-GH	X	..	..	H	..	X	H	X	..	..	X	X	..	..	..	..	M
Flexol 4-GO	X	..	..	H	..	X	H	X	..	..	X	..	..	..	..	..	M
Polyethylene glycols	X	..	..	H	..	X	H	X	..	..	X	..	..	..	..	..	M
Miscellaneous																	
Castor oil	..	..	..	X	..	X	H	..	..	..	X	X	X	..	..	..	M
Acetylated castor oil	..	..	..	X	..	X	H	..	..	..	X	..	X	..	..	..	M
Butyl acetyl ricinoleate	..	..	..	..	..	X	H	..	..	..	X	..	X	..	..	..	M
Oleic acid	X	..	..	X	..	X	H	..	..	..	..	X	X	..	..	..	M
Aroclors	X	..	..	X	X	H	X	X	X	X	X	X	X	X	X	X	L
Hydrogenated terphenyl (HB-40)	X	..	A	X	X	X	X	X	X	..	..	..	X	..	X	X	L
Ortho-nitrobiphenyl (ONB)	..	..	..	X	X	X	..	X	..	..	..	..	X	..	X	X	L
Acetyl tributyl citrate	X	..	X	X	X	X	X	X	..	..	X	X	..	..	..	..	M
Glycerol triacetate	X	..	..	X	X	X	X	X	..	..	X	X	..	..	..	..	M

[a] Properties considered for those resins with which the given plasticizer is most commonly used.
A—Toxicity work indicates these compounds to be of very low order of toxicity. They have not yet been approved by the BAI or FDA.
X—Denotes special value.
H—Denotes exceptional value.
L—Denotes low cost.
M—Denotes average cost.

that it is one of the few plasticizers that finds utility in nylon. The solid plasticizers, Santicizer 1-H, and Santicizer 3, are used in delayed tack, heat-sensitive adhesives because of their melting points being within the ideal range for such type plasticizers.

Adipates. The adipates are outstanding for their ability to impart flexibility to the various resins. The higher molecular weight esters are the most important because of the low volatility they have.

Sebacates. The sebacates are similar to the adipates in their outstanding flexibilizing action and have the advantage of additional permanence, but the disadvantage of high price, uncertain availability, and susceptibility to fungal attack.

Polymerics. The polymeric type plasticizers resist extraction and are outstandingly nonvolatile. Several of these so called "polymeric" materials recently marketed are actually epoxidized soya oil. These have primary utility as stabilizers for resins such as polyvinyl chloride. When used in this role, their concentration may well be 5 to 10% of the total plasticizer content. Being naturally derived products, most of them are susceptible to fungal attack. Normally, the polymerics are not efficient plasticizers and are difficult to incorporate in the resin and some methods of paper coating applications are impossible because of the high initial viscosity and slow fusion characteristics of these plasticizers.

Glycol Derivatives. The glycol derivatives of monocarboxylic aliphatic acids are excellent on the basis of their flexibilizing action. They have a shortcoming of being somewhat more water sensitive than most high molecular weight plasticizers currently used. They probably represent the maximum limit in water sensitivity that is permissible for normal plasticizer applications.

Miscellaneous. Castor oil finds utility primarily in cellulose nitrate coatings. The ricinoleates are favorable for flexibility and softening properties, but are limited in compatibility and are food for fungi. The chlorinated and hydrogenated terphenyls and biphenyls (Aroclors and HB-40) are primarily useful as plasticizer and resin extenders to reduce formulation cost. Acetyl tributyl citrate is a primary plasticizer approved for nontoxicity. Triacetin (glycerol triacetate) is primarily a cellulose acetate plasticizer although it is somewhat water sensitive.

Included in the miscellaneous group are some plasticizer extenders which must be used in combination with primary plasticizers in order to maintain complete compatibility.

Plasticizers in Vinyls

Table VI lists the performance, permanence, and cost of various plasticizers in polyvinyl chloride. This resin was selected because it is the largest tonnage resin employing plasticizers, and since the properties of the plasticizer as given here also apply to the other members of the vinyl series including polyvinylidene chloride and copolymers and polyvinyl acetate and copolymers.

The data indicate that dibutyl phthalate has performance characteristics which are favorable but its high degree of volatility makes it less desirable than phthalates such as DOP, Santicizer 160 and particularly di(*n*-octyl-*n*-decyl) phthalate (DnODP). The significance of this volatility factor was recently interpreted by H. M. Quackenbos (*1*) when he showed that a film containing dibutyl phthalate would lose 10% of its weight in 3 months and a similarly DOP plasticized film would require 27 years to lose the same percentage of plasticizer by way of volatilization.

Aryl groups in a plasticizer are less flexibilizing than alkyl groups but generally are favorable for permanence and flame resistance. For example, Santicizer 160 is not as flexibilizing as DOP but has greater resistance to extraction by kerosene and lower migration to Linde silica. Also Santicizer 160 is slightly more flame retardant. A similar comparison can be made in the phosphate series. Trioctyl phosphate is extremely flexibilizing but is highly extractable with kerosene and is not especially flame retardant. Tricresyl phosphate shows poor flexibility but excellent resistance to extraction and is flame retardant.

The adipates and sebacates support the theory that the more efficient a plasticizer is for imparting flexibility, the more readily it will be extracted by oil. In reviewing this table, it will be noted that all plasticizers with excellent flexibility show extremely high oil extraction. The polymeric plasticizers, being somewhat deficient on flexibilizing action, are very low in oil extraction.

APPLICATION OF PLASTICIZERS IN SPECIFIC RESIN COATINGS AND ADHESIVES

The general properties imparted by plasticizers discussed heretofore can be further illustrated by selecting a few specific resins and pointing out the plasticizers useful with them for specific applications.

Nitrocellulose

Dibutyl phthalate is considered the standard plasticizer for nitrocellulose lacquers. It offers a combination of good solvent effects on the resin, good efficiency and permanence properties adequate for some uses. Lately, however, because of increased demands for greater permanency, greater water resistance and hydrocarbon resistance, Santicizer 160 has been finding considerable favor. Dioctyl phthalate is also replacing dibutyl phthalate in applications where lower volatility is desired.

Solid plasticizers such as dicyclohexyl phthalate or Santicizer 3 and heat sealing resins such as Santolite MHP are used in making moisture resistant heat sealing paper lacquers. A typical formulation is:

SS nitrocellulose 1/2 sec.	50 parts
Santolite MHP	10 parts
Dibutyl phthalate or Santicizer 160	15 parts
Dicyclohexyl phthalate or Santicizer 3	14 parts
Dewaxed dammar	8 parts
Paraffin wax, 135°F.	3 parts

This is made up to 20 to 25% solids in a solvent mixture composed of ethanol, butanol, toluene, ethyl acetate, and butyl acetate.

Raw castor oil can be used in a nitrocellulose general purpose lacquer as a plasticizer that offers good flexibility and good block resistance, but in many applications has the objectionable characteristic of bad odor.

Cellulose Acetate and Cellulose Acetate-Butyrate

Santicizer M-17 and Santicizer E-15 are excellent nontoxic plasticizers with good permanence characteristics, grease resistance, light stability, and efficiency for cellulose acetate resins. A plasticizer combination consisting of dimethyl phthalate, diethyl phthalate, and triphenyl phosphate in the approximate ratios of 33 1/3% each offers an excellent economic plasticizer system with optimal properties. Cellulose acetate has recently been introduced in a form capable of formulating into hydrosols. Following is a typical hydrosol formulation for a grease resistant, nontoxic coating:

Cellulose acetate LL-1	30 parts
Santicizer M-17	20 parts
Water	49.85 parts
Thickening agent	0.1 part
Stabilizer	0.05 part

Cellulose acetate-butyrate has recently been formulated in a half-second type and the following formulation is typical:

1/2 sec. cellulose acetate butyrate	20 parts
Santolite MHP	3 parts
Santicizer B-16	1 part

This is made up to a 25% solids solution in a solvent system

consisting essentially of toluene, acetone, ethyl alcohol, and isobutyl acetate.

Ethyl Cellulose

One of the principal advantages of ethyl cellulose is the relative ease with which it can be plasticized. This makes it possible to use lower cost petroleum oils as plasticizers where their odor and color can be tolerated. Ethyl cellulose has found usage in the form of hot melts which usually contain paraffin, ethyl cellulose, a vegetable wax, resin, and plasticizers. In choosing a plasticizer, solvent power is a prime consideration; low volatility at the operating temperature and freedom from odor, taste, and toxicity, are other necessary requirements. The following formulation is illustrative of an ethyl cellulose hot melt with excellent low temperature flexibility, good heat sealing characteristics, and a low moisture-vapor transfer:

Ethyl cellulose	15 parts
Beckacite 2000	15 parts
Staybelite	20 parts
Dibutyl phthalate or dioctyl phthalate	5 parts
Paraffin wax, 135°F.	25 parts
Hydrogenated castor oil	20 parts

Polyvinyl Acetate

Plasticized polyvinyl acetate latices are particularly useful for adhesives for bonding paper to paper, or paper to foil, because of their quick tack development, excellent flexibility and toughness, grease resistance, and moisture resistant qualities. Polyvinyl acetate and copolymer polyvinyl acetate also find use in hot melt formulations for book binding.

A typical formulation for a polyvinyl acetate nontoxic, grease resistant coating is as follows:

Elvacet 81-900 or Gelva S-55	100 parts
Santicizer B-16	3.5 parts
Tri-Pure	7.0 parts
Water	15–30 parts

Delayed tack, heat-sensitive type adhesives can be made from polyvinyl acetate and solid plasticizers. An example of this is as follows:

Polyco 117-SS	100 parts
Diphenyl phthalate	100 parts
Filler	0–20 parts
Water	10–15 parts

A typical formulation for a polyvinyl acetate hot melt for book binding is as follows:

Neville hard resin	61.4%	mix and heat at 250–275°F. until melted
Santicizer 160	15.0%	
Paraffin wax	6.4%	

Then, raise temperature to 300–325°F. and agitate after adding:

Vinylite AYAA	12.9%
Ethyl cellulose	4.3%

In general, in polyvinyl acetate the higher molecular weight phthalates such as DOP are incompatible. However, Santicizer 160 is compatible and offers improved permanence and grease resistance over dibutyl phthalate. Santicizer 141 and Santicizer B-16 are permanent, nontoxic, grease resistant plasticizers.

Polyvinyl Chloride and Copolymer Vinyl Chloride–Vinyl Acetate

Vinyl resins are used in paper coating in the form of solvent solution coatings, latices and organosols and plastisols.

Copolymer vinyl chloride-vinyl acetate resins plasticized with nontoxic, grease resistant plasticizers such as Santicizer 141, Santicizer B-16, and Santicizer M-17 have been used for coating paperboard containers for milk, lard, ice cream, etc. The plasticizer imparts flexibility, aids in solvent release and heat sealing characteristics. A typical formulation is as follows:

Vinylite VYHH	80 parts
Vinylite VMCH	10 parts
Vinylite VAGH	10 parts
Santicizer 141	25 parts

Table VI. Comparative Performance, Permanence, and Cost of Several Plasticizers in Polyvinyl Chloride

	Properties							
Plasticizers	*Low temperature flexibility, °C.*	*Shore hardness*	*Flame-out time, sec.*	*Plasticizer extracted by water, %*	*Volatility: % plasticizer lost*	*Plasticizer extracted by kerosene, %*	*Migration: plasticizer absorbed by Linde silica (1 day at 25°C.), %*	*Cost*
Phthalates								
Dibutyl	−39	72	..	0.11	60.5	25.1	..	Medium
Dioctyl	−37	73	>100	0.02	4.5	80.0	2.0	Medium
Butyl benzyl (Santicizer 160)	−23	72	45	0.05	12.0	6.1	1.6	Low
Di(*n*-octyl-*n*-decyl)	−46	75	..	0.13	1.8	85.6	5.1	Medium
Phosphates								
Trioctyl	<−60	75	>100	..	7.9	72.6	5.0	High
Tricresyl	−10	78	0	0.01	1.0	3.0	0.4	Medium
Cresyl diphenyl (Santicizer 140)	−16	77	0	0.01	3.4	8.0	1.5	Medium
Aklyl diaryl (Santicizer 141)	−37	73	38	0.02	5.5	20.6	4.0	Medium
Adipates and sebacates								
Dioctyl adipate	<−60	70	>100	0.10	13.0	91.0	9.5	High
Diisobutyl adipate	<−60	70	..	1.12	73.8	..	..	High
Dioctyl sebacate	<−60	75	..	0.34	1.3	..	11.0	High
Polymerics								
Paraplex G-25	−19	77	>100	0.04	0.52	1.0	0.25	High
Paraplex G-50	−18	82	>100	0.05	0.7	3.8	0.88	Medium
Paraplex G-60	−28	76	..	0.0	0.4	16.2	..	Medium
Miscellaneous								
Flexol 4-GO	−55	74	..	2.13	14.9	26.5	..	Medium

40-Mil sheet at 40% plasticizer concentration:
Low temperature flexibility—method of Clash and Berg, *Ind. Eng. Chem.* 34: 1218.
Hardness—A scale.
Flame-out time—burning time after heating 30 sec. with Bunsen burner.
Volatility—heated 24 hr. at 105°C. in air circulating oven.
Kerosene extraction—96 hr. at 27°C.
Water extraction—ASTM D570-42.
Migration—J. R. Geenty, Third Annual Proceedings of SPI—1951.

Make up to a 20 to 25% solids solution in acetone or acetone-methyl isobutyl ketone solvent mixture.

Latices of vinyl chloride plasticized with DOP, DnODP, and Santicizer 141 are useful in paper coatings. For latices, plasticizers which are efficient in their plasticizing action as well as good solvents for the resin are generally required so that a tough, homogeneous film can be developed with moderate baking temperatures and in short periods of time. A typical formulation is as follows:

Phase 1:
Pliovic latex 300 or Geon latex 351 or 352 ..... 100 parts
(55% solids in water)
Phase 2:
Water 37.5
Ammonia, 28% 0.6
Morpholine 0.4
Dioctyl phthalate, Santicizer 141, or DnODP 60.0
Oleic acid 1.5

To 100 parts of phase 1, add 50 parts of phase 2.

Plastisols and organosols offer a means of laying down a high solids vinyl coating. Generally, it is desirable to maintain uniform viscosity characteristics of the plastisol or organosol over extended periods of time prior to application. For this reason, plasticizers which have a low solvency on the resin at room temperature are desired. On the other hand, it is desirable to use a plasticizer that has good solvency at an elevated temperature so that low temperatures of fusion and fast cycles may be maintained. It has been found that the best method to accomplish this is through a blend of nonsolvent and solvent type plasticizers and by using viscosity reducing agents in the organosol or plastisol system. The following data illustrate the viscosity build-up of a dioctyl phthalate plasticizer system and how a viscosity reducing agent can control viscosity build-up:

Composition	*Viscosity, cp.* 2 hr.	1 day	1 week	1 month
Geon 121, 100 pt. Dioctyl phthalate, 85 pt.	2400	4000	6000	9000
Geon 121, 100 pt. Dioctyl phthalate, 85 pt. Polyethylene glycol 400 monolaurate, 0.5 pt.	1870	2450	3200	4500

If organosols or plastisols are formulated and used immediately by the processor, then viscosity stability is not as critical a problem as good fusion characteristics.

The following formulation is suggested as a starting point for an organosol or plastisol coating formulation. This formulation has excellent heat and light stability, good low temperature flexibility, excellent fusion qualities, and good grease resistance and heat sealing characteristics:

Geon 121	100 parts
Dioctyl phthalate, di iso octyl phthalate or di(*n*-octyl-*n*-decyl) phthalate	34 parts
Santicizer 141 or Santicizer 160	13 parts
Paraplex G-60 or G-62	3 parts
Dyphos	5 parts
Atomite	0–20 parts
Apco thinner	20–30 parts

Vinylidene Chloride and Copolymers

Polyvinylidene chloride and copolymers have excellent chemical resistance and resistance to moisture-vapor transfer as well as low gas transmission. Plasticized vinylidene resins have been coated on paper via hot melt extrusion. Santicizer E-15 and Santicizer 141 are excellent plasticizers for Saran and are completely nontoxic. They aid in heat sealing and impart improved low temperature flexibility.

In solvent cast copolymer vinylidene chloride resin solutions, plasticizers impart improved flexibility and aid in solvent release. Generally, only small percentages of the

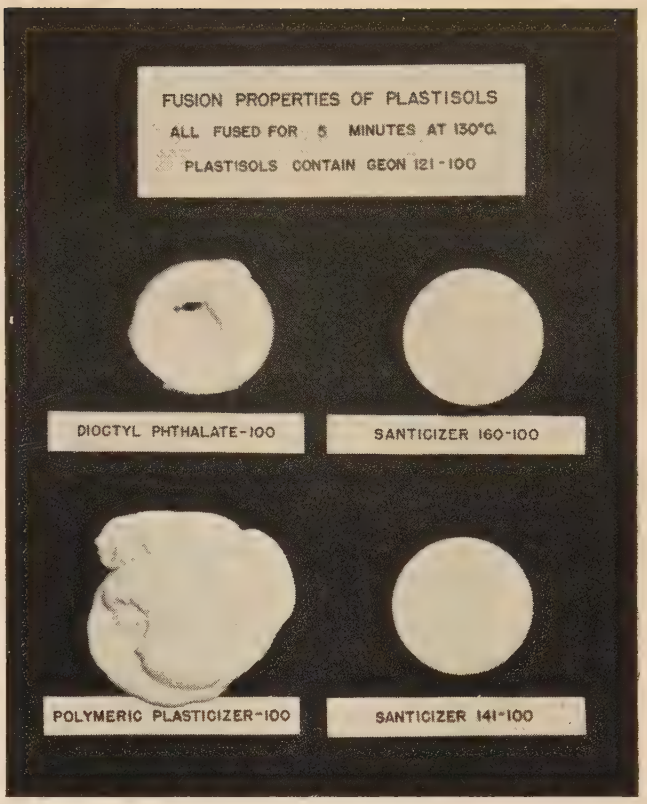

Fig. 2. Fusion characteristics of plasticizers in a polyvinyl chloride plastisol

plasticizer are required to produce a high degree of softness and elongation. For example, films containing 25% of Santicizer B-16 with Saran F-120 resin will possess over 300% elongation. Since plasticizers reduce chemical resistance as well as moisture-vapor resistance, it is important to select a plasticizer which is efficient in action. The phthalyl glycolates are very good in this respect, as are Santicizer 141, dibutyl phthalate, dibutyl sebacate, and diethyl phthalate. Nonsolvent type plasticizers such as butoxy ethyl stearate, butyl stearate, and stearic acid are useful for removing tack and raising the block point of coatings. Only small percentages (1 to 10%) should be used of the nonsolvent type.

Vinylidene chloride latices such as Dow latex 744-B are finding considerable interest in the paper coating trade. Plasticizers are essential to lay down a continuous film and one free from pinholes. Plasticizers which speed up the rate of fusion of latex particles aid in giving a pinhole-free coating. Strong solvent type plasticizers aid in heat sealing. Santicizer 141 is excellent in this respect and is superior to dioctyl phthalate and tricresyl phosphate. Stilbert and Clack (*2*) have reported extensively on vinylidene latices for paper coating. The properties that are imparted by plasticizers generally coincide with the data given in this paper for straight polyvinyl chloride resins.

Nylon and Polyamides

Polyamide suspensoids give good heat seal bonds to other surfaces and enhance the water and grease resistance of paper. Plasticizers are added to the suspensoids to increase flexibility and tack, lower the softening and heat seal temperatures and to improve gloss. Strong polar plasticizers such as the sulphonamides are extremely useful for imparting tack and laying down continuous films.

Nylon can be solution coated onto paper and imparts excellent oil resistance. Santicizer 8 is one of the most effective type plasticizers for nylon, imparting good grease resistance and flexibility.

Zein

Zein may be plasticized to give a heat sealing, greaseproof paper coating or may be used to give glossy, scuff resistant label varnishes. The following formulation is useful as a spirit varnish for label coating:

Zein A	100 parts
WW rosin or Vinsol resin	75 parts
Santolite MHP	5 parts
Santicizer 8	8 parts
Proprietary solvent	300 parts

The following formulation is a typical greaseproof, heat sealing paper coating:

Zein A	100 parts
Staybelite	40 parts
Oleic acid	25 parts
Santicizer 141 or Santicizer B-16	25 parts
Proprietary alcohol	190 parts

Chlorinated Rubber

Chlorinated rubber may be used as a base for moisture vaporproof coatings for paper and paperboard. The following formulation is suggested as a nonblocking, moisture vaporproof coating:

Parlon, 125-cp. type	23.8
Teglac 2-152	8.3
Dibutyl phthalate or Santicizer M-17	6.0
Wax Barnsdall special	1.9
Toluene	60

Thermosetting Resins

Phenolic Resins. Phenolic resins are used for impregnating and laminating paper to form useful molded sheets, rods, tubes, and molded objects. Occasionally additional flexibility is desired for cold or hot punching of electrical parts. Dibutyl phthalate or Santicizer 160 have good electrical qualities, and at a concentration of 5 to 10% based on the weight of the phenolic resin impart suitable punching and flexing characteristics. Tricresyl phosphate may be used where some degree of flame retardancy is desired along with greater flexibility.

Melamine and Urea Resins. Melamine and urea resins are used for decorative coatings on paper based laminates. Plasticizers such as the toluene sulphonamides and in particular Santicizer 9 offer improved flow characteristics, greater solution stability, and allow drying to low moisture contents prior to laminating. Normally 15 to 25% plasticizer is employed based on the weight of the resin.

Polyester Resins. Polyesters, based on styrene, maleic anhydride, or fumaric acid and phthalic anhydride, can be made more flexible through the use of 15 to 25% by weight of certain plasticizers such as Santicizer 160, Santicizer M-17, Santicizer 141, and tricresyl phosphate.

CONCLUSION

Plasticizers are the formulators' key to successful processing of a resin paper coating and are essential for maximum utility of the various resins offered. Plasticizers should be selected with a proper balance of processing characteristics, performance, permanence, and cost.

LITERATURE CITED

1. Quackenbos, H. M., Fourth Annual Proceedings of the Society of Plastics Industry, Section 3, page 4.
2. Stilbert and Clack, *Tappi* 34, No. 8 (Aug., 1951).

CHAIRMAN: Thank you very much, Mr. Bergen, for an excellent and very comprehensive paper on the subject of plasticizers.

MR. SPENCER (Knowlton Bros.): You mentioned Santicizer 8 with nylon. What is the method of application?

MR. BERGEN: The method of application is generally in a solvent solution—alcohol and water-type system. Solvent-type nylon is used.

MR. SPENCER: What benefit is derived?

MR. BERGEN: It imparts additional flexibility to the system.

MR. SPENCER: Will it increase tear?

MR. BERGEN: You will improve film formation. Mechanical properties are not generally improved. They are maintained. Santicizer 8 is effective because small amounts maintain the physical properties yet give good flexibility. Other plasticizers give good flexibility but hurt the tear strength.

QUESTION: With Santicizer 8, what quantities are recommended to be effective and yet not affect the ultimate properties of nylon?

MR. BERGEN: Normally, 20% by weight on the resin.

QUESTION: You mentioned something about the internal method of plasticizing polyesters. Would you say something about that versus the use of plasticizers?

MR. BERGEN: In polyesters you use adipic acid and sebacic acid to give flexibility and, with the vinyl copolymers there have been used butadiene-acrylonitrile copolymers which will give an internal plasticization. These materials certainly have some advantages and it is a problem of economics and plant handling techniques, which one the supplier wants to use. In other words, with the resins that require plasticizers you have great flexibility. By adding a little more, you make it softer; or you take less and have it more rigid. So, the advantage of the straight vinyl system is the flexibility you have in plant handling.

In the copolymer type, you have a certain defined, type of material and many times the economics are in favor of the vinyl type over the copolymer type but both have definite fields of use.

QUESTION: Did I understand you to say cellulose acetate?

MR. BERGEN: Yes. Hercules has been offering LL-1. That is just the acetate. They don't offer the hydrosol. You have to make that yourself.

CHAIRMAN: If there are no further questions, we will proceed with the next paper to be given by Mr. Arledter of the Hurlbut Paper Co. on "The Use of Inorganic Synthetic Fiber Paper for Laminates." This is a very new field and I am sure you will all find it most interesting.

Uses of Inorganic Synthetic Fiber Paper

HANNS F. ARLEDTER

AMERICAN research and industry has solved, in the last years, the problem to manufacture a number of synthetic inorganic fibers which prove to be usable for papermaking purposes.*

Some of these fibers are now, after appreciable price reductions in the last year, in the price range which makes them interesting for the manufacture of absorbent papers for the laminating industry.

Our research lab has been working for approximately 3 years on the development of synthetic fiber paper in general. One of our aims was to develop absorbent paper for laminates in which special features which cannot be met with cellulosic-base papers are wanted. We had in mind to produce a paper

HANNS F. ARLEDTER, Director of Research, Hurlbut Paper Co., South Lee, Mass.

* Thomas D. Callinan of the Naval Research Laboratory was the first to have made paper of 100% submicron glass fibers with a paper machine of the Bureau of Standards. (Callinan, T. H., Lucas, R. T., and Bowers, R. C., "The Electrical Properties of Glass Fiber Paper," Naval Research Lab., May, 1951.)

Table I. General Description of a Selection of Inorganic Synthetic Fibers

	Quartz-glass	*Na-glass*	*Aluminum silicate*	*E-glass*
Chemical composition	100% SiO_2	78.2% SiO_2 21.8% $Na_2O(K)$	49% Al_2O_3 49% SiO_2 1% B_2O_3 $^1/_2$% Na_2O	54.3% SiO_2 15.5% Al_2O_3 16.3% CaO 9.9% B_2O 4.7% Na_2O
Softening or melting point, °C.	1500–1600	~570	1560–1750	750–800
Dielectric constant, 50 H_z	3.5–4.2	6–7	5–6	5–6
Dielectric losses, 20°C.	0.000	0.01–0.03	...	0.0018–0.005
Dielectric losses, 200°C.	0.01–0.05	Not measurable	...	~0.01 (≶)
Volume resistivity, 20°C. in Ω·cm.	$>10^{15}$	5×10^{11}	$>10^{14}$	10^{14}
Volume resistivity, 200°C. in Ω·cm.	3×10^{13}	$<10^{8}$ (not measurable)	$>10^{13}$	$\sim 10^{12}$

made of glass fiber which can be processed similarly as cellulosic-base papers.

The following discussion outlines what we achieved so far or what may be expected in the future. Please note that this is partly a progress report of a research lab. From pilot plant state to production is sometimes a long step, and we try to present to you mainly features which we are reasonably sure can be manufactured. A number of successful glass fiber paper runs have been made in our mill and a number of glass fiber paper or aluminum silicate paper grades are now available.

This progress report today is limited to absorbent paper grades developed for the benefit of the laminating industry especially for polyester, DAP, epon, melamine, and phenolic resin applications.

The author reported about inorganic synthetic fiber paper grades bonded with silicone, Teflon, or inorganic binder especially for class H insulation purposes or condenser fields on April 15, 1953, before the Electrochemical Society.

Synthetic inorganic fiber absorbent grades for the laminating industry have naturally to compete with (1) cellulosic absorbent papers, (2) asbestos paper, (3) glass cloth, (4) mica paper, and (5) glass mat.

Each of these products has its own merits and it is not the intent to replace such conventional absorbent papers if they do the job satisfactorily. In some respects, though, absorbent paper made of inorganic synthetic fibers gives a better performance or later may be of interest pricewise. It should therefore be able to supplement cellulosic papers, glass cloth, glass mats, or asbestos papers in new and old fields.

GENERAL DESCRIPTION OF INORGANIC SYNTHETIC FIBERS

It is astonishing how many new inorganic fibers were developed in the last few years. At the moment, fibers of the nature of different glass compositions, aluminum silicate, kaolin, quartz, silicate, etc., are available in either pilot plant or production amounts. From all these fibers we have been able to make paper.

Table I shows some general properties from a selection of inorganic synthetic fibers. The choice of such fibers for special laminated products has to be made according to the properties required in the final laminate.

Table II outlines certain basic properties in the laminate which can be improved if glass fibers instead of cellulose fibers are employed for the absorbent base paper.

With the help of inorganic synthetic fibers a number of special features can be incorporated into the laminate. The use of lead glass yields, for instance, a paper product which can serve as a filter for radiant energy and which may give a lead equivalent of a fraction of a millimeter or more.

PHYSICAL PROPERTIES OF GLASS FIBER PAPER

At first it looked quite simple to develop inorganic synthetic fiber papers for the laminating industry, but after we worked for a while in this field the problems mounted. The laminating industry has many different requirements in regard to the properties of the base paper as well as the final laminate.

The laminator uses different solvents, different resins, different working methods for the impregnating, treating, and pressing and we soon found that one product could not meet all these demands. We became resigned, therefore, to the necessity of developing custom-made products for special uses.

You have to realize, therefore, that grades we have developed so far may not fit your special needs at this time. On the other hand, the solution for your problem may be already in our files.

Table III outlines the principal differences between conventional cellulosic absorbent papers and our newly developed inorganic fiber paper grades, the manufacture of which proved to be feasible in our pilot plant production.

You may observe that in regard to dry strength, cellulosic paper grades are still superior to the inorganic fiber papers. You will see later, this is not necessarily true for the final laminate. In regard to wet tensile, some of our developments prove that it is possible to obtain similar over-all tests to those of the present base papers, if the proper binder is employed based on solvent system used for resin.

The question to be raised is: where is it necessary to increase the dry tensile strength of inorganic fiber paper? For some cases the wet strength achieved now may be sufficient; for others we will have to make improvements to meet the demand of the trade.

Another basic difference between cellulose paper and glass paper, for instance, is the specific gravity. You will note that the density of cellulosic papers can be 50 to 100% higher

Table II. Comparison of Properties of Cellulose Fibers versus Inorganic Fibers

	Cellulose fibers	*Inorganic fibers*
Effect of acids	Fibers disintegrate	Depending upon fiber material, effect is slight to appreciable
Effect of alkali	Swelling and reduced strength	Attacked
Effect of other chemicals	Attacked by strong oxidizing agents	None to slight
Water absorbency	27% at 95% R.H. Total Retention >100 to 127%	Up to 0.3%
Effect of heat	Loses strength above 300°F. Decomposes at 350–450°F.	Not influenced up to 600 to 2200°F.
Burnability	Burns readily	Does not burn
Electrical properties	Good at low moisture content Extremely bad at high relative humidity	Excellent at low relative humidity. Good at high relative humidity

Table III. Cellulose Absorbent Paper versus Glass Absorbent Paper

	Hurlbut Paper Co. base paper grades						
	521	504	314	249	1451	247	934-CH
Fiber material	Cellulose	Cellulose	Glass	Glass	Glass	Glass	Glass
Binder designation	...	...	A	B	D	C	None
Basis weight, lb. (24 × 36—500)	88	81.5	61	65	60	56.7	36
Thickness, mil	10.4	9.8	11	12	12	10.32	8.4
Specific gravity, g./cc.	0.512	0.54	0.35	0.34	0.326	0.36	0.28
Density	8.4	8.3	5.5	5.2	5.0	5.5	4.3
Densometer, $1^1/_8$ in.	22.2	23.4	0.5	0.6	4.8	1.2	6
Dry tensile, g./in.	9950/5650	9300/5800	2750/1500	1400/1100	2350/1500	1650/1150	700/ 400
Tear, g.	96/120	104/112	32/40	28/32	40/48	28/32	40/48
Klemm	10	14	8	None	12	None	32
Schopper wet tensile, g./in.	400	400	1150	950	425	1400	540
Penetration, sec.							
Melamine (50% water)	3	2	Inst.	None	Inst.	None	Inst.
Phenolic (alcohol + benzol solvent, $s = 0.95$)	2	1	Inst.	Inst.	Inst.	Inst.	Inst.
Low pressure resin solution (P-43 + 12% styrene)	6	22	22	Inst.	Inst.	22	Inst.
Wet stretch, %	2/0.4	3.4/0.7	0.0	0.0	0.0	0.0	0.0
Tensile, g./in. (wetted with resin solution for 60 sec.)							
Melamine (50% water)	520	550	800–900	...	300	1100	580
Phenolic (alcohol + benzol solvent, $d = 0.95$)	2100	2100	Poor	300	500	450–600	580
Low pressure resin solution (P-43 + 12% styrene)	3500	4200	Poor	500–600	1100–1800	200	650
Light fastness	Good	Good	Good	Fair	Fair	Poor	Excellent

than the glass fiber paper. In our efforts we did try to raise the specific gravity up to 0.4, while we were able, on the other hand, to lower the specific gravity of the paper to 0.2 or less.

Table IV presents a comparison between decorative cellulosic absorbent papers and glass absorbent papers containing white pigments.

Theoretically all opacified or colored decorative absorbent paper grades which are feasible with cellulose fibers can also be manufactured with the help of inorganic fibers.

Glass fiber paper prints well in general and printability is sometimes improved. Glass fiber paper grades do show, therefore, promises for the decorative laminating field.

Table IV. Comparison Between Pigmented White Absorbent Cellulose Paper and Pigmented White Absorbent Glass Fiber Paper

	Hurlbut Paper Co. base paper grades		
	500-L cellulose	340-B glass	344-B glass
Basis weight, lb. (24 × 36—500)	97.5	69.5	66
Thickness, mil	7.9	13.1	11.6
Specific gravity, g./cc.	0.806	0.345	0.37
Density	12.3	5.3	5.7
Densometer, sec.	75.6	2	1.4
Dry tensile, g./in.	7900/4300	2400/1900 1700/1680	2150/1500
Tear, g.	72/96	24/40	32/40
Klemm	10	31	None
Schopper wet tensile, g./in.	1400	550–900	1350 No penetration
Ash (filler), %	16.4	18	18
Penetration, sec.			
Melamine (50% water)	5	5	No penetration
Phenolic (alcohol + benzol solvent, $d = 0.95$)	2	0.5–inst.	2
Low pressure resin solution (P-43 + 12% styrene)	52	28–17	18
Wet stretch,			
Machine	0.6	0.00	0.00
Cross	2.9		
Bursting strength, lb.	16.8	...	...
Opacity	Good	Good	Good
Light fastness	Good	Good	Fair
Tensile, g./in. (wetted with resin solution for 60 sec.)			
Melamine (50% water)	1700	620	No penetration
Phenolic (alcohol — benzol solvent, $s = 0.95$)	3430	400	440
Low pressure resin solution (P-43 + 12% styrene)	5000	400	400
Binder	...	A	B

PROBLEMS IN THE MANUFACTURE OF INORGANIC FIBER PAPER

The main problems in the manufacture of inorganic fiber paper for the laminating industry are connected with the proper selection of fibers and binder materials. Inorganic fibers alone in general do not give sufficient bonding and such papers do not give, therefore, the required over-all strength. Although we developed paper grades which can be used in the laminating industry binder-free, the incorporation of a binder into the more inexpensive glass fiber paper grades to obtain the over-all strength is unfortunately necessary.

In Table III you can see that the proper selection of the binder for the given application has to be done carefully. Requirements in regard to light fastness, resin penetration time, and strength of the impreganted sheet are the points to be mainly considered.

There does not seem to be, at the moment, one binder which is able to meet all requirements, although we hope to find one someday. Principally we have, at the moment, four binders selected which may give sufficient results for the start.

We have checked so far more than 80 different binder systems so that we are pretty well informed about possibilities in this regard.

PROBLEMS IN THE MANUFACTURE OF LAMINATES MADE OF INORGANIC SYNTHETIC FIBER GRADES

In general, glass fiber paper may be usable in the future in

Table V. Resin Pickup

Melamine solution—50% solids

Method of impregnation	Resin pickup, %			
	Cellulose absorbent paper	Glass paper		
Hurlbut Paper Co. base paper grade	521	307	249	315
Dipping, no press roll	67	78	80	82.5
Dipping plus press roll				
Press setting I	57.5	61	66	71
Press setting II	57.5	55	62	59
Press setting III	57.5	55	62	59

Table VI. Precure Time, Precure Temperature, and Flow for Cellulose Absorbent Papers versus Glass Fiber Paper

Melamine solution—50% solids

	Cellulose paper	*Glass fiber paper*
Resin content, %	~66	~66
pH of paper	5.0	6.5
Precure temperature, 130°C		
Precure time, sec.	330	1200
Flow, %	~6	6–20
Precure temperature, 140–142°C		
Precure time, sec.	...	300
Flow, %	...	2–4

the manufacture of laminates in a similar way as cellulosic absorbent papers. In some regards this may be possible today, but in many cases modifications in the working procedure may prove beneficial or necessary.

Table V gives information regarding the resin pickup.

Cellulosic absorbent paper with a specific gravity of 0.5 does pick up, for instance, a resin amount of 67% if dipped in a melamine or phenolic resin bath without pressing. A glass fiber paper with a specific gravity of, for example, 0.3 may pick up a resin amount of 82.5% if no pressing is employed. Under these circumstances unfavorable working conditions would be encountered with glass fiber paper. The necessary precure time might increase from four to six fold to obtain proper resin flow.

In making your trials you should try therefore to employ the press roll method to incorporate the proper amount of resin into the paper. Only very slight pressing should be exercised. A paper grade which has a resin pickup of 82.5% without press roll yields a resin pickup of around 60 to 70% with the press roll. Resin pickup for glass fiber paper for press roll applications is seemingly directly connected with the specific gravity or the density of the glass fiber paper. Pressing of the paper beyond the amount which can be determined from the density may cause damage to the glass paper structure, whereas such a pressure would not harm cellulosic paper.

The resin pickup can be reduced with changing concentration of the resin solution. This does not help the economics in the operation, as the precure time will still be higher.

Table VI gives data regarding the precure of melamine treated paper. We found that the precure time of glass fiber paper, melamine, or phenolic treated (if a similar formula and the same precure temperature as for cellulosic base paper is employed), will be higher for the neutral glass absorbent

Table VII. P-43 (Rohm & Haas)—Laminates Made of Glass-Base Paper versus Cellulose-Base Paper

	—Hurlbut Paper Co. base paper grade— 505-C	X-934
Fibers used	Cellulose	Glass
Thickness, in.	0.062-0.068	0.078-0.083
Resin content, %	72.3	84.7
Barcol hardness	55	63
Flexure test		
Lengthwise ultimate strength, p.s.i.	19,300	18,400
Modulus of elasticity, p.s.i.	11.06×10^5	6.83×10^5
Crosswise ultimate strength, p.s.i.	14,500	15,500
Modulus of elasticity, p.s.i.	7.40×10^5	6.24×10^5
Water absorption, 24 hr.		
25°C. soak		
Solubles, %	Negligible	Negligible
Total gain, %	1.45	0.38
100°C. soak		
Solubles, %	1.95	3.54
Total gain, %	9.46	2.82
Appearance	Opacity around sanded edges	Became opaque

Table VIII. Electrical Properties of Glass versus Alpha-Cellulose Paper Laminates Made with Paraplex P-43[a]

Before and after immersion in H_2O for 24 hr.

	Alpha-cellulose as absorbent paper	*Glass fiber paper, Hurlbut Paper Co. grade 934 as absorbent paper*
Thickness of laminate, mil	62–68	78–83
Resin content, %	72.5	84.5
Dielectric constant "as is"		
60 cycles	4.6	3.6
10^3 cycles	4.2	3.5
10^6 cycles	4.0	3.4
Dielectric constant after immersion in water—24 hr., 25°C.		
60 cycles	6.7	3.8
10^3 cycles	4.9	3.6
10^6 cycles	4.1	3.5
Power factor "as is"		
60 cycles	0.089	0.021
10^3 cycles	0.032	0.019
10^6 cycles	0.033	0.020
Power factor after immersion in water—24 hr., 25°C.		
60 cycles	0.21	0.043
10^3 cycles	0.12	0.027
10^6 cycles	0.039	0.027

[a] Results obtained by Mr. Wirsch, Rohm & Haas Co.

paper. Raising the precure temperature about 10 to 15°C. gives, though, similar results.

The author could expand his remarks in regard to resin pickup, precure time, flow, and other adjustments which may be wanted for glass fiber paper but space limits this discussion. It is intended, therefore, to discuss some of the properties of laminates made of cellulosic base paper versus glass fiber base paper.

PROPERTIES OF LAMINATES MADE OF INORGANIC FIBER PAPER

Table VII gives some properties of Rohm & Haas Paraplex Polyester P-43 laminates. It will be noted in the table the strength of the glass laminate is somewhat similar to that of cellulose laminates. The base paper used in this laminate is one of our first developments and we hope to be able to increase the strength of the laminate in which glass fiber paper is employed. At the present state of development it has not been finally achieved in all regards.

If you compare Table VIII you will find that the differences in the electrical performance of cellulose versus glass are quite marked. The table is, in this regard, self-explanatory.

Table IX compares the strength of cellulose and glass Melmac 405 laminates. I am indebted to Mr. Lindenfelser of American Cyanamid Co. for these test results.

The abrasion resistance of glass paper laminates versus cellulose is better or the same, depending upon the method of measuring the abrasion resistance. In some tests, the abrasion resistance readings were up to 40% higher, but in no case lower than for cellulose.

The heat resistance of the glass paper laminate and dimen-

Table IX. Alpha-Cellulose and Glass Fiber Paper Melamine Laminates[a]

Melmac 405 resin, American Cyanamid Co.

	Hurlbut Paper Co. base paper grade 521	306
Fibers used	Cellulose	Glass
Thickness, in.	0.0165	0.016
Resin content, %	58.5	77
Impact strength, ft.-lb/in.	0.26	0.39
Flexural strength, av. p.s.i.	21,100	17,000

[a] Results obtained from Physical Testing Laboratory, American Cyanamid Co.

Table X. Electrical Resistance of Laminates

	Volume resistivity, ohm-cm. Relative humidity 95–98%	55%	0%
100% cellulose	4×10^9 (10^8)	6.2×10^{11}	10^{15}
100% glass (+ binder)	7×10^{12}	1.5×10^{14}	$>10^{15}$
75% glass, 25% rag	1×10^{10} (10^9)	7.8×10^{11}	$\sim 10^{15}$

sional stability of the laminates are, with other points, improved. In some tests like water spotting or fiber show of overlays, glass does not give the expected good results. Similar results as obtained now with glass mat or glass cloth may be expected.

The behavior of glass paper laminates versus cellulose paper laminates in varying relative humidity is shown in Table X. Again similar results may be expected as with glass mat or glass cloth.

Glass fiber paper shows some drawbacks as a transparent overlay for melamine, or phenolic resins for electrical applications, but glass fiber paper gives, though, a very good electrical performance if combined with a cellulosic base paper core as can be seen in Table XI.

SPECIAL DEVELOPMENTS OF INORGANIC FIBER PAPER FOR THE LAMINATING INDUSTRY

A number of glass fiber papers usable for decorative purposes and for electrical applications have been discussed.

Table XI. Electrical Resistance of Laminates After Exposure to 95–100% Relative Humidity

Cellulose-base paper	$\sim$50,000 $\mu\Omega$
Glass-base paper	$\sim$2,000,000 $\mu\Omega$
Cellulose-base paper plus glass overlay paper	$\sim$1,000,000 $\mu\Omega$

We have also on file some newer developments in which combinations of inorganic fibers and either organic synthetic fibers or papermaker fibers in small amounts or both are combined.

Our decorative paper 0-305 was developed to obtain improved properties in regard to resin penetration rate, printability, dimensional stability, etc. Table XII will give some idea of what properties can be expected from a paper of this kind. This is again a pilot plant development and we do not know how well we can repeat the paper performance on the big paper machine, but you might be interested in our development work in this line.

Another pilot plant absorbent grade which may prove of interest is our grade 0-332. This absorbent paper increases flameproof properties and electrical properties in laminates at the same time. Table XIII outlines results.

In conclusion it may be stated that inorganic fiber paper for laminates should be considered if you are looking for the following properties:

1. Improved electrical performance under varying heat and moisture conditions.
2. High dimensional stability.
3. Low moisture pickup of the laminate.
4. Improved chemical resistance.
5. Improved heat resistance.
6. Flameproofness of laminate.
7. Decorative sheet with high penetration speed and improved over-all properties in comparison with cellulose base paper.

Table XII. A New Decorative Absorbent Paper (Pilot Machine Product: 0-305) versus Standard Decorative Absorbent Grades (499-L and 500)

	Hurlbut Paper Co. base paper grades 0-305 glass	499-L cellulose	500 cellulose
Basis weight, lb (24 × 36—500)	82.5	103	64
Thickness, mil	9	8.8	5.6
Melamine penetration 50:50, sec.	1.5	5.4–20	2.1
Low pressure resin penetration, sec.	12	72	25
Wet stretch, %	1.2	3.2	2.5
Oil test, sec.	1.2	4	5
Opacity			
High pressure laminate	Very good	Good	Good—(fair)
Low pressure laminate	Good	Very good	Good—(fair)
Water absorption in laminate: 24 hr., 25°C.	0.9	2.4	...

Table XIII. Phenolic Laminates Made with Flameproof Paper versus Glass Paper and Cellulose Paper

	Hurlbut Paper Co. base paper grade 0-332 flameproof	521 cellulose	0-315 glass
Hurlbut Paper Co. laminates burning test	Does not burn	Burns readily	Burns readily
Is flame self-supporting?	No	Yes	Yes
TAPPI flammability test, height of destroyed area, in.	1/4 to 1/2	2	1
Afterglow	None	Strong	Short
Structural strength of laminate 20-mil, g./in. after exposure to 1500°F	15,000	0	13,000
Electrical tests after exposure to moisture	Good	Poor	Good
Dimensional stability	Excellent	Fair	Excellent
Water absorbency (boiling water)	0–0.2	1.8–3.2	0–0.2

OUTLOOK

This discussion has presented some facts about our developments in the manufacture of inorganic absorbent papers for the laminating industry. Such paper will be available in the near future in a variety of thicknesses, absorbency, density, containing filler or colors, and other properties. The intention has been to show you the scope of different possibilities, and the author wishes to point out again that up to date a special job may require custom-made absorbent papers.

There still remains much work to be done and the results will depend highly on the close cooperation of the research chemists and chemical engineers of the paper mill and the laminating industry.

The author wishes to express here his appreciation for the cooperation of all his co-workers who did their share in the development work.

CHAIRMAN: Thank you very much, Mr. Arledter!

It is a paper we are all very grateful to hear. This subject marks an evolution of an infant in the paper industry, and I am sure the future will witness ever increasing use of glass fiber in the papermaking process.

QUESTION: I'd like to ask Mr. Arledter if the phenolic resin used on the last slide was the same in all cases?

MR. ARLEDTER: Yes.

QUESTION: Why would it burn on one laminate and not the other?

MR. ARLEDTER: Our flameproof absorbent paper grade 0-332 does contain a high amount of flameproofing material which does not increase or decrease the absorbency of the paper.

MR. LINDENFELSER (American Cyanamid Co.): On the phenolic laminate, you said it was exposed to 1500°F. and you gave a figure of 15,000 remaining. What kind of strength was that?

MR. ARLEDTER: It was a tensile strength figure. We took a strip 1 in. wide and placed it in the oven for 1 to 2 min. at 1500°F. The organic material is removed and a black substance remains consisting of some carbon and glass. This strip tested gives a tensile figure of 15,000 grams per in.

In the case of a paper containing aluminum silicate fibers (0-334) the burning temperature can be raised up to 3000°F. and you still obtain the same high tensile strength. Such a paper grade shows with 1500°F. a tensile strength of 15,000 grams per in. also.

Mr. Lindenfelser: One minute exposure?

Mr. Arledter: Yes, and you can expose it practically indefinitely at 1500°F. if an aluminum silicate paper is employed.

Mr. Lindenfelser: You mean the resin binders are burnt off leaving the glass behind?

Mr. Arledter: Correct. It seems that one obtains some kind of a carbon-glass mixture after the burning.

Mr. Lindenfelser: In your table—you gave, for instance—a figure for tensile strength of 1400/1100. Does that represent range of values? On glass you gave figures of 2400/1000.

Mr. Arledter: The figures represent the average tensile test figures for machine and cross direction.

Question: You gave us a table showing that 20% rag will ruin all dielectric properties.

Mr. Arledter: If the fiber can pick up moisture from the air.

Question: I wonder, instead of using cellulose fiber, if one couldn't use viscose acetate or rayon, and if they could be combined with the glass we should get some properties that might modify the poorer characteristics of the glass sheet.

Mr. Arledter: In the last paragraph of my paper I spoke about special developments. I mentioned at this place that we are using mixtures between synthetic organic and inorganic fibers with or without the addition of cellulose. Such combinations were investigated rather thoroughly and in two grades mentioned in our tables we did use mixtures between organic synthetic fibers and inorganic synthetic fibers.

Question: And the water pickup is lessened?

Mr. Arledter: Naturally, if the organic synthetic fibers employed are of the proper kind.

Mr. Sixsmith (du Pont): How is wet tensile strength in glass paper measured?

Mr. Arledter: Two ways. We use a strip of paper 1 in. wide and dip the same 1 min. in the resin solution, or water, clamp it in the tensile equipment, and measure the straight tensile. We found the Finch tensile strength test cannot be used for glass fiber paper because the glass fibers may break on the small loop used in the Finch test.

Mr. Sixsmith: The glass had been dried previously?

Mr. Arledter: No, we dip the paper 1 min. in the solution; take it out, and make the test within 30 sec.

Question: How do you feel about glass fiber paper competing with glass cloth and glass mat?

Mr. Arledter: That is something I couldn't answer at the moment. I don't know. I am a research man and don't go into price problems too much.

Question: In comparing the glass fiber paper grades the same laminated characteristics were used. Your tables do not show the influence of fiber length and other features.

Mr. Arledter: Correct, but I presented glass fiber paper grades that proved to be feasible in production. We have lab paper grades with increased or decreased fiber length and with other paper characteristics. It is, though, no use to tell you about these because such papers may not be feasible or practical at the moment, but paper with higher strength may come in the future.

Mr. Chen (American Machine & Foundry Co.): At what temperature would the binder mentioned in your paper break down the electrical tests? Do you find any binder, such as silicons, will improve the properties of the paper?

Mr. Arledter: I mentioned at the start of my paper that the paper grades discussed were developed for the laminating industry and not for Class H insulating materials. I mentioned also that I reported in April, 1953, before the Electro-chemical Society about the results on glass fiber paper bonded with Teflon and silicon.

If you are interested in base papers for laminates for the temperature range above 180°C., you will have to use paper grades bonded with Teflon or silicon. My paper today was only concerned with the lower temperature range.

Question: You gave a figure of five something in density.

Mr. Arledter: In paper mills, density is calculated by dividing the basis weight in pounds per ream by the thickness of the paper in mils. My tables did show the specific gravity below the density column; therefore you have both figures available if you are more familiar with specific gravity.

Mr. Wilkinson (Monsanto Chemical Co.): Can you modify the tensile strength by fiber length and what is the maximum fiber length used?

Mr. Arledter: In the lab there are practically no restrictions, but on the paper machine there are definitely limitations regarding the fiber length. These limitations will depend also on how your machine is operating or built. The possible fiber length range is so wide that it is not possible to answer your question. At the moment we believe to have in our paper grades a fiber length range which yields a fair strength.

Chairman: Mr. Arledter, you mentioned something that interested me. You touched on the matter of printability of glass paper. Since glass is known to have excellent elasticity, would you expect eventually to provide a better printing surface?

Mr. Arledter: Glass fibers have a diameter of 0.5 to 5 mu and cellulose fibers have a diameter of maybe 15 to 40 mu. The number of fibers per square inch is, due to this fact, increased. In general, it can therefore be stated that glass fiber papers yield, in the average, a very good, improved printing surface. Some of our finer glass paper grades yield a surface which could be regarded as the ideal surface texture for printing.

It is interesting to note that glass fiber paper gives a very good printing even if the paper has a rough surface. In general, the fact that a rough surface cannot be printed well does not apply in all cases for glass fiber paper.

Chairman: If there are no further questions, I will thank Mr. Arledter again and proceed with the next paper, "Experimental Roll Coating of Polyethylene-Wax Blends," by G. L. Booth of the Dilts Machine Works.

Reverse Roll Coating Experiments with Hot Melt Resins

G. L. BOOTH

The purpose of this paper is to familiarize the paper and plastics industry with the experimental work performed for the determination of machinery applicable to handle the hot melt resins on the market. In this study and development, a four-roll reverse roll coater called the Contracoater* was used because a reverse roll coater is more versatile than other types of coaters.

Therefore, this paper may be considered a progress report covering development work during the past year with many types of hot melt resins, most of which are familiar to you. This paper deals primarily with the mechanical and functional aspects of the reverse roll coater including the rheological properties of various coatings resulting from reverse roll application.

For this paper, hot melt coatings will be defined as any

G. L. Booth, Senior Research Engineer, Dilts Div., The Black-Clawson Co., Fulton, N. Y.

* Trade-mark.

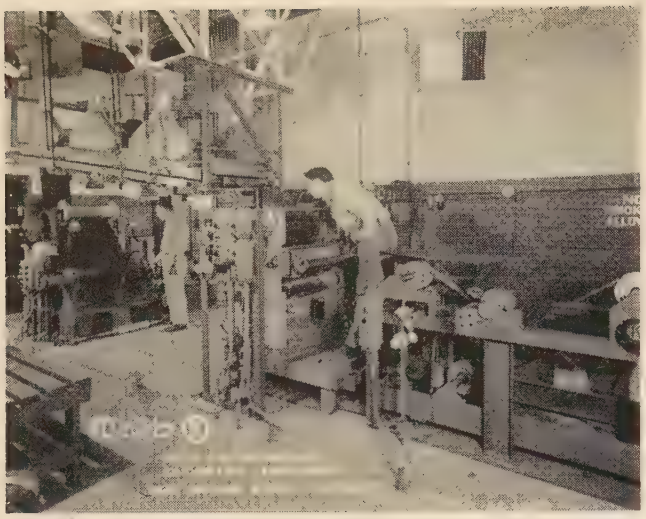

Fig. 1

compound or blend of compounds that are normally solids at room temperature and require heat rather than diluents, dispersants, or solvents to produce the liquid state necessary for coating application. The hot melts which are discussed include (1) polyethylene-wax blends including blends of high and low molecular weight polyethylene with either paraffin or microcrystalline wax; (2) polyamide resins; (3) paraffin wax; (4) carnauba wax, and (5) asphalt. These coatings have required temperatures ranging from 170 up to 350°F.

MACHINERY

All work and developments related in this paper have been accomplished on the pilot coating machine in the Converting Laboratory of The Black-Clawson Co., Dilts Div., in Fulton, N. Y.

The over-all layout of machinery is best shown and described by reference to Fig. 1. The uncoated roll of material is placed in the constant tension unwind stand as shown. The web lead is underneath the coater, up the back side, around the rubber back-up roll, and into an electric radiant heat oven. After the oven section, the coated material is led over two 16-in. diam. cold rolls prior to rewinding. In the case of very light papers, a dancer roll controlled winding operation is used. For fabrics and heavy papers, however, the dancer roll is by-passed and current regulation winding is used since heavier tensions are possible. Line speeds of 300 f.p.m. can be obtained on this machine. Maximum web width for this machine is 18 in.

Since the coating section is the heart of this machine and pertinent to the main subject of the paper, a detailed description of the coater is included.

Figure 2 shows the Contracoater four-roll reverse roll coater from the drive side. The bottom or pick-up roll is 8-in. diam. tubular steel, chrome-plated, and serves to pick up coating from the pan. It may be rotated in either direction through

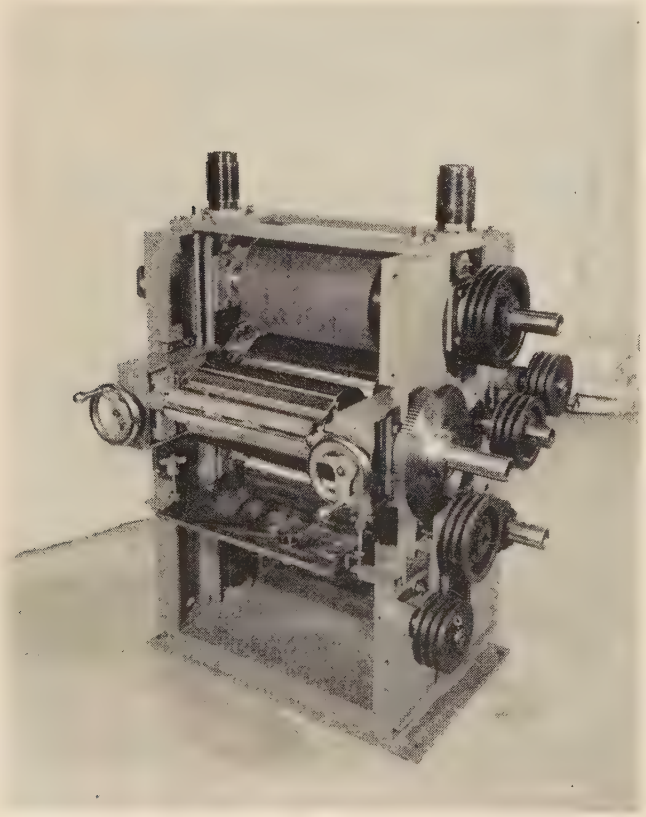

Fig. 2

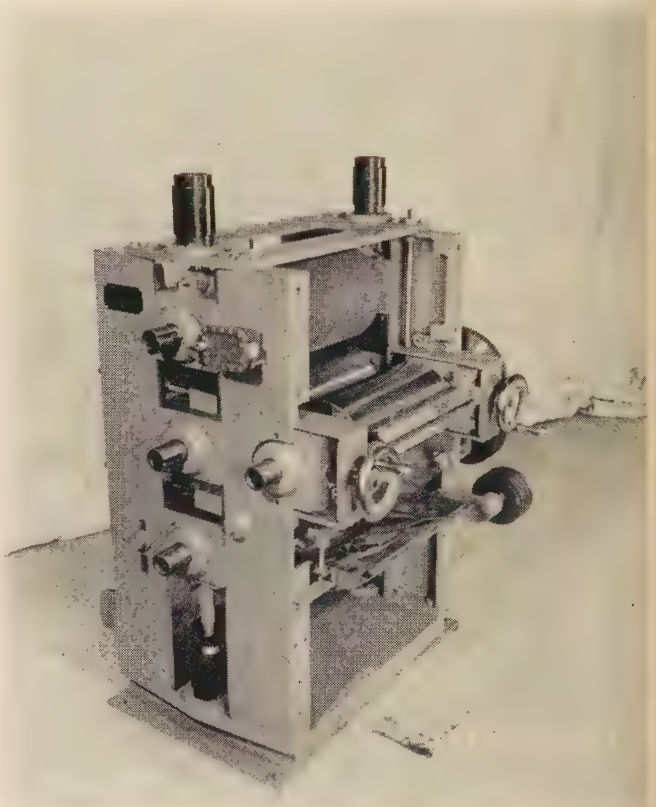

Fig. 3

adjustment of the drive. The middle or applicator roll is a 10-in. diam. accurately ground, chilled iron roll, and is carried in precision bearings, to eliminate variation in coating caused by eccentricity. This roll is always run counter to and in contact with the web. The metering roll is an 8-in. diam. chilled iron, chrome-plated, accurately ground roll which is run in counter rotation to the applicator roll. It, too, is carried in precision bearings. Its sole function is to meter the thickness of coating being deposited on the applicator roll. A cleaning doctor is placed on this roll as shown.

The 10-in. diam. neoprene-covered roll serves as a drive and backing for the web. In this particular machine, the neoprene is 60 Shore A Durometer. The rotation, like the applicator and metering rolls, is clockwise.

It should be kept in mind that the objective in reverse roll coating is to apply a measured amount of coating on the applicator roll and then apply this measured amount on the web to be coated.

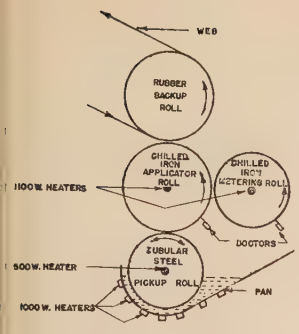

Fig. 4

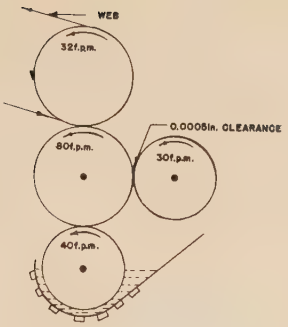

Fig. 5. Contracoater setup for Morax N

To adjust the three nips formed by the four rolls, sliding, tapered wedges between the bearing housings are used as shown in Fig. 3. The sole purpose of these blocks is to act as stops between the rolls, and to allow the operator to return to a given setting in case a roll is pneumatically retracted for some reason.

Tests run on the pilot machine have shown a variation of less than 0.0002 in. in wet coating deposited along and across the web. In the case of some hot melt resins, this variation can be decreased through a different method of operation for reverse roll coaters as described later.

Temperature control was a vital factor in most of the hot melts used. To show the method used for heating, reference is made to Fig. 4. The metering roll and applicator roll were each heated by an 1100 watt heater mounted in a stationary position inside the roll. The pick-up roll was heated by a 550-watt unit. The pan containing 30 to 40 lb. of coating was heated with seven 1000-watt strip heaters mounted on the underside. Operating temperatures of 350°F. were obtained with no unusual difficulty. Wipe ratios between the rolls can be instantly varied due to the drive arrangement. The speed of the applicator roll can be varied from the same as the web up to six times web speed. By use of an independent motor on the pick-up roll, the wipe ratio can be instantly varied from 1:1 down to 1:10 in relation to the applicator roll, and through a mechanical transmission and motor, the metering roll can be varied over a range of 8:1 in relation to the applicator roll. By changing the mechanical drives on any of these rolls, the relative speeds can be further changed with the same speed variations as listed above.

POLYETHYLENE-WAX BLENDS

The first resin to be discussed is a blend of polyethylene and wax. The development of these blends is perhaps of greatest interest to the plastic coatings industry today. At present, the development of machinery to handle these blends is behind the actual development of the blends (*1*).

Some of these materials are in the extruding range although the vast majority are below 25,000 cp. viscosity and must necessarily be applied by roll coating methods (*2*).

The development of roll coating methods has not yet reached the stage at which these blends can be used commercially, although the primary difficulties have been overcome.

These coatings used to date range from 40 to 60% polyethylene having a molecular weight from 12,000 to 19,000 with the remainder of the blend made up of paraffin and/or microcrystalline wax. Viscosity ranges have been 6000 to 25,000 cp. at 350°F. (*3*).

Blends having a viscosity under 15,000 cp. have been successfully coated using the roll arrangement shown in Fig. 5. Using a 0.5 mil metering nip the coating deposit was 1 mil with less than 0.2 mil variation along and across the web.

A somewhat radical coater speed relationship was tried to reduce the coating thickness variation and from preliminary results, it would appear that it may be the answer to this most difficult problem of thickness variation in roll coating. Figure 6 shows a proposed arrangement. Note that the applicator roll is running at one half the web speed. With polyethylene-wax blends, there is a tendency for the coating to "neck down" or "stretch out" during application, so through use of this characteristic it is possible to run the applicator roll slower. Thus, if there is a 0.2-mil variation in the coating while operating the machine with a wipe ratio of 2:1 between the applicator roll and the web, this variation of 0.2 mil will be reduced to 0.05 mil with a wipe ratio of $^1/_2$:1. With polyethylene-wax blends used in the laboratory a high gloss has not been developed in the coating due to improper chilling. To solve this problem, work is presently under way to develop machinery for bringing out the gloss.

To date, the extrusion method of coating the higher viscosity blends has produced more satisfactory results from a gloss standpoint although an extruder has not yet been used commercially with these blends. Preliminary results indicate that reverse roll coating will effect better lamination of the coating to the paper, give superior heat sealability and better moisture vapor transmission rate.

The capital expenditure necessary to set up a reverse roll coating line is approximately the same as for a comparable extrusion coating line, but the conversion cost will be less for roll-coated paper than for extrusion-coated paper. There is less maintenance and greater versatility with roll coating too.

These blends will be cheaper than pure polyethylene, and in turn will utilize wax which in itself has better MVT characteristics than polyethylene. These blends will be used for coating in essentially the same way as polyethylene is today.

POLYAMIDE RESINS

Two polyamide resins, formulations containing polyamides, 94-S and 95-S in the range of 6000 to 10,000 cp. viscosity Brookfield at 300°F., have been tried on the reverse roll coater. Both polyamides had a molecular weight of 3000 to 6500. Polyamide 94-S had a softening point of 105 to 115°C. and polyamide 95-S had a softening point of 95 to 105°C. using ASTM ball and ring (*4*). Both resins were applied to a 20-pt. chipboard having a clay coating on one side.

It was found that the reverse roll coater handled the polyamides with surprising ease. No real coating difficulty was encountered in any trial even though various combinations of roll speeds were tried. The best roll ratio found was that shown in Fig. 7. It should be noted that a wipe ratio of 2:1 existed between the applicator roll and web. Also of interest was the slow rotational speed of the pick-up roll to eliminate air entrainment in the coating reservoir.

To illustrate the fine coating control with polyamides on

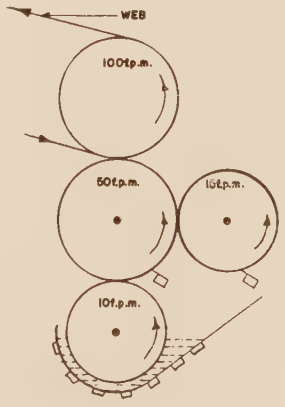

Fig. 6. Proposed "Contracoater" arrangement for reducing thickness variation

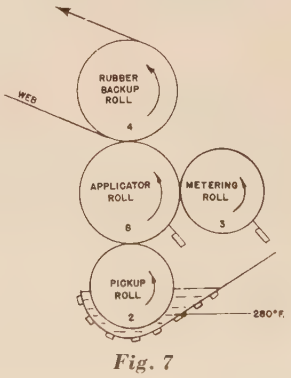

Fig. 7

this coater, a $^1/_2$-mil coating deposit having 1% wax gave a moisture vapor transmission rate of only 2.97 grams per sq. meter per 24 hr. and a greaseproof test of 1800 sec. both flat and fold. This is proof of the pinhole-free coating that was accomplished. The surface of the coating was very smooth and glossy even though no sudden chilling of the coated sheet was used.

It would appear that no fundamental modifications are necessary in the coater to produce commercially acceptable polyamide coated products.

These coatings can be used for chemical and oil resistant coatings, greaseproof, moistureproof, and heat-sealing coatings. Because of their relatively low softening point, they find ready use in heat-seal coatings. They are not compatible with paraffin waxes over 2 to 4% unless rosin or a rosin ester is used as a mutual solvent. With use of wax the MVT characteristics of the coatings are enhanced (*5*).

PARAFFIN WAXES

Paraffin waxes with a melting point of 143 to 145°F. have been tried using an 86-lb. bleached sulphite cup stock for the tests.

Two grades of paper were used with one having normal sorbancy and one having abnormal sorbancy. The reasons for this testwork were to determine (1) how low a wax content could be metered, (2) what precision was obtainable, and (3) what normal waxing variables could be eliminated. In conventional two or three-roll waxing machines, the machine speed, wax temperature, paper temperature, squeeze pressure between the rolls, and rubber roll hardness affect the wax content. In the laboratory trials, a premetered amount of wax was applied using a coater setup as shown in Fig. 8. It should be noted that the pick-up roll was operated at a greatly reduced speed.

It was found that the metering roll had to be run against the applicator roll by retracting the stops between these two rolls in order to control wax content below 5 lb. per TAPPI ream and that the pressure between the two rolls determined the wax content. Using a pressure of 27 lb. per lineal in. against the metering roll, the resulting wax content was 1.3 lb. per ream ± 10%. By decreasing this pressure to zero, the wax content jumped to 5 lb. per ream. Above 5 lb. per ream, a positive nip clearance obtained by use of stops between the rolls was used to meter wax content. Throughout the entire testwork, the web was held against the applicator roll with 15 lb. per lineal in. pressure to insure complete pickup.

The paper having a high sorbancy rate was tried and no change in coating weight was found. The paper was heated prior to waxing and again no effect on wax content was noted. The wax temperature and machine speed did have some effect on the wax content.

In summation, it may be said that the reverse roll principle and premetered wax application indicate possible elimination of some of the present waxing variables. With control of wax content within 0.13 lb. per ream, a very precise waxing operation can be carried out. However, unless versatility and precision control below 5 lb. per ream wax content are necessary, the reverse roll coater has no future competing with conventional squeeze roll waxers which are less elaborate in design and are quite capable of satisfactorily controlling wax content to about 3 lb. per ream.

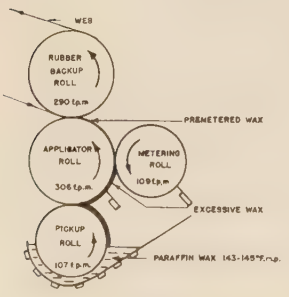

Fig. 8

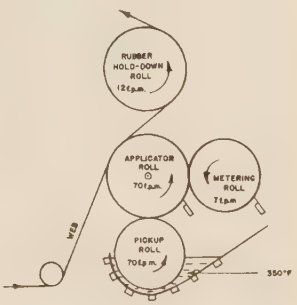

Fig. 9

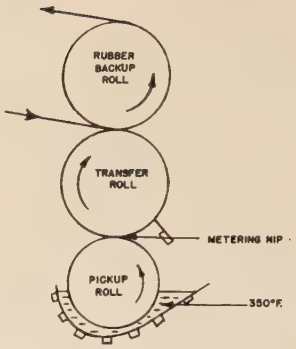

Fig. 10

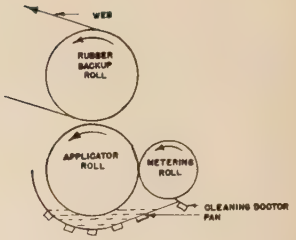

Fig. 11. Three-roll reverse roll coater using pan

CARNAUBA WAX

A synthetic wax similar to carnauba wax was used in the pilot plant. It had a melting point of 210°F. although it was coated at a temperature of 250°F. Since this wax displayed essentially the same characteristics on the reverse roll coater as paraffin, no further discussion is necessary.

ASPHALT

Asphalt coating is usually considered a rather simple operation, and during the course of routine investigation, the laboratory had an opportunity to coat a creped kraft sheet with an asphalt-rubber blend which is used as a laminant in multiwall bag manufacture. This particular blend had a viscosity of 12,000 cp. Brookfield at 350°F.

It was found that complete coverage of the creped sheet could be accomplished with a 3.5-mil coating deposit, a 50 lb. per lineal in. loading on the back-up roll, and a 3:1 wipe ratio.

The reverse roll coater did an excellent job of coating, however, precision product quality would have to be required to justify the capital expenditure. The range of coating deposit could be from a fractional mil up to about 20 mils maintaining precision control. Heat of the melt would have some influence on variation of coating weight, although it would not be as pronounced as with standard asphalt applicators. The influence of temperature is most apparent in the shear characteristics of the coating during the metering process between the applicator and metering roll. If the temperature is changed the viscosity will change accordingly setting up a different shear force at the nip formed by these two rolls at constant relative speeds. Thus, the amount of coating coming through the metering nip would change (*6*).

A kiss coating procedure shown in Fig. 9 was tried with this combination of asphalt and creped paper without much success because insufficient pressure of the paper to the applicator roll caused skip coating. The web tension was insufficient to wipe the applicator roll clean thus necessitating a back-up roll for this operation. On Fig. 10 another method is shown using three vertically stacked rolls. The coating produced on this machine was acceptable although the inherent control of a reverse roll coater is lost. Further, since edge doctoring was done on the center transfer roll, a small bead of coating flowed around the end of the edge doctor and onto the coated portion of the sheet. This condition gave a beaded edge to the coating thus making it detrimental to the coated product.

SUMMARY

In closing, it should be pointed out that other hot melts have been used in the pilot plant for development purposes.

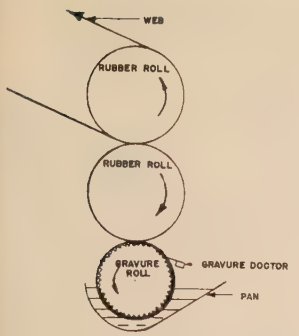

Fig. 12. Ordinary offset gravure coating

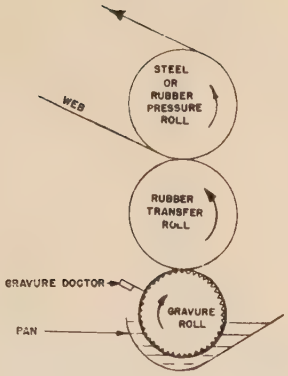

Fig. 13

Note: Rubber transfer roll to run at greater speed than web and in opposing direction.

Some of these include polyvinyl acetate, heat-seal coatings, other paraffin waxes, microcrystalline waxes, and carbon coatings.

The fundamentals that have been learned since the inception of this work include (1) the necessity to operate the pick-up roll at a greatly reduced speed, (2) employment of the "necking down" feature of some coatings to reduce coating thickness variation, (3) the use of zoned electrical heating in the rolls, (4) the necessity of chilling some coatings quickly to develop gloss, (5) accurate control of pan temperature, (6) methods for elimination of streaked coatings, and (7) the limitations of the four-roll reverse roll coater.

Certainly a three-roll reverse roll coater shown on Fig. 11 is satisfactory for some applications when oxidation of the coating is no problem. Heat-seal coatings, carbon coatings, and some waxing operations can be performed on this machine. The gravure coater shown in Fig. 12 is acceptable when the coating deposit is always the same (*7*). Perhaps its greatest use is for heat-seal coatings for label stock.

Of interest are recent tests made using a rotogravure coater having a sand-blasted roll with four separate patterns on it (*8*). Using microcrystalline wax of m.p. 165°F., wax was deposited ranging from 1.6 up to 3.7 lb. per TAPPI ream. Perhaps this innovation will cut the cost of gravure coating rolls somewhat thereby making it possible to keep a larger and more diversified inventory of rolls on hand.

Further, an idea is presently being pursued to eliminate partially the disadvantage of nonversatility in gravure coaters. This is best explained by reference to Fig. 13. It will be noted that a definite amount of coating is brought up by the gravure roll and offset to the rubber roll. From this rubber roll, the metered coating is applied to the web which is backed up by either a steel or rubber roll. In such an arrangement, accurately ground rolls are unnecessary since the pattern on the gravure roll does the metering, rather than a nip. Thus, if there is some heat distortion of the roll it will not affect the coating since the coating is transferred to the rubber roll by squeeze contact. This method probably will not be acceptable for hot melts over 225°F., since the wear on the rubber roll would be excessive.

Finally, and probably of greatest importance, the laboratory in which this work has been conducted is sufficiently versatile to try all of the proposed methods herein listed. Certainly every conceivable idea is worth a try and that is exactly what the future plans are.

LITERATURE CITED

1. E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., "Alathon Polyethylene Resin (Extrusion Coating)," Information Bulletin No. X-37.
2. Bakelite Corp., Div. of Union Carbide & Carbon Corp., "Polyethylene Resins, Coating and Adhesive Materials," Technical Releases Nos. 7 and 8.
3. Bakelite Corp., Div. of Union Carbide & Carbon Corp., "Polyethylene for Paper Coatings (Technical Data)," Copyright 1951.
4. General Mills, Inc., "Polyamide Resin," Technical Bulletin (April, 1951).
5. Wittcoff, Harold, Renfrew, M. M., and Spryer, Fred B., *Tappi* 35, No. 1: 21–29 (Jan., 1952).
6. Smith, Wilson J., Trelfa, Richard T., and Ware, Harris I., *Tappi* 33, No. 5: 212 (May, 1950).
7. Technical Association of the Pulp & Paper Industry, "Machinery for Paper Coating," TAPPI Monograph, Series 8, New York, 1950.
8. The Black-Clawson Co., Inc., Dilts Machine Works Div., Laboratory Reports: C-131-1, "Laboratory Development Work of Polyethylene-Wax Blends Using the 'Contracoater'"; C-131-2, "Laboratory Development Work of Polyethylene-Wax Blends Using the 'Contracoater'"; C-131-3, "Laboratory Development Work of Polyethylene-Wax Blends Using the 'Contracoater'"; C-142, "Dry Waxing of Drinking Cup Stock Using the 'Contracoater'"; C-143, "Asphalt Coating with the 'Contracoater'"; C-151, "Laboratory Waxing Operations"; C-154, "Hot Melts Resins Application with the 'Contracoater.'"

CHAIRMAN: Thank you, Mr. Booth.

Due to the lateness of the hour I will ask we postpone any questions on this paper until immediately after lunch.

MR. NAZZARRO: I will call the afternoon session to order. I will turn the meeting over again to Mr. Pullman, who will conduct the rest of the session.

CHAIRMAN: First, I will call for any questions relating to the last paper given on the coating machine by Mr. Booth of the Dilts Machine Co.

MR. HOSMER (General Electric Co.): I am trying to recall what coating weights you said you had with the straight wax. Did I hear you say you had a pound of wax per ream? By applying the increased pressure on the metering roll against the applicator roll? Is that on an impervious basis? I think you mentioned cup stock—a standard cup stock?

MR. BOOTH: It was standard cup stock paper that was used in both cases—an 86-lb. sheet, but one had a higher sorbancy rate especially in a standard dry waxing operation. We were very successful in keeping it on the surface.

MR. HOSMER: With both types of paper?

MR. BOOTH: Yes—because you get away from the squeeze roll application, you can set it on the surface.

MR. HOSMER: You set it on the surface by controlling temperature?

MR. BOOTH: That is right, the inherent operational characteristics of the reverse roll coater will put it on the surface.

MR. YODER (Pyroxylin Products): I believe that there are blends being produced at the present time which can be procured in commercial lots.

MR. BOOTH: One thing I'd like to bring up at this time. I previously stated I knew of no place where polyethylene wax blends were being used commercially. I have since found out that these coatings are being produced commercially using the extrusion method of coating.

MR. DREIS (P. H. Glatfelter Co.): You made a comment about the metering roll chattering when you had a heavy load going up through the nip. What is the limiting factor? Is it more pressure, or more uniform pressure?

MR. BOOTH: I would say more pressure. You are holding the metering roll in place. At the present time in our machine we have 300-lb. Baumbach square wire springs and evidently they are not quite sufficient to hold the metering roll in place under load. Also, I believe if that roll were rotated at a higher speed it would tend to alleviate that condition. I am not positive on that. That, again, is something we don't know.

MR. YODER: Have you experienced oxidation of the coating in your pan?

MR. BOOTH: We have experienced oxidation in the pan primarily because we use strip heaters fastened directly to the

bottom of the pan. This pan was constructed of 12-gage stainless steel and localized superheating did occur directly above the heaters, thereby causing some oxidation or carbonization. However, we are aware of this and are presently altering our pan so that the heat will be more uniformly distributed to prevent this localized superheating of the melt in the pan.

Most of these coatings have to have antioxidants in them to prevent oxidation. However, during the blending process in the manufacture of these blends, they were violently agitated with air being beaten into the blend while at high temperature. No oxidation was experienced in the blending of these compounds. Therefore, the small amount of aeration at the elevated temperature in the coating pan would not seriously affect the oxidation of the coating blend.

CHAIRMAN: If there are no further questions, thank you very much, Mr. Booth, and we will proceed with the next paper which is called "Polyethylene Extrusion Lamination Techniques" and will be given by H. A. Arbit of the Bakelite Co.

The Polyethylene Extrusion-Lamination Technique

H. A. ARBIT

ALTHOUGH the synthesis of high molecular weight polyethylene was accomplished in England in 1933, this plastic is a relative newcomer to the synthetic resins. The first large-scale commercial production of polyethylene was started in the United States by divisions of Union Carbide & Carbon Corp. in 1943. The development of this thermoplastic material has been nothing short of phenomenal. The production of polyethylene for the year 1952 is conservatively set at 125 million lb. with an estimate of over 500 million lb. for 1955 based on expanding production facilities. Approximately one third of the total annual production is used in packaging applications, a field in which polyethylene laminates are playing an increasingly important role.

The subject of this paper is extrusion-lamination—specifically extrusion-lamination of polyethylene. The properties of bakelite polyethylene which enhance its potential as a functional coating are well known. They include water and water-vapor resistance, low-temperature flexibility, chemical and grease resistance, heat sealability, tear resistance, inertness, thermal stability, large surface coverage per pound, and declining cost due to efficient, expanding production.

The extrusion-lamination technique is a relatively new, one-step method of applying polyethylene directly to paper, cellophane, foil, or cloth and combinations of these to create unique packaging materials which combine the merits of each constituent. The increase in use of this method is logical since it eliminates the cost of producing unsupported film, of adhesives, and of the subsequent lamination in a two-step method. It eliminates the use of solvents, drying, recovery systems, and the associated fire hazards of solution coating. It allows for high coating speeds and coating thicknesses as low as a half mil.

The meaning of the term extrusion-lamination is actually self-explanatory. In general, polyethylene or polyethylene mixtures are extruded in the conventional screw-type extruder and through a flat film die. As the molten resin leaves the die lips it is pulled into the nip of two driven squeeze rolls located directly beneath the die. As the subcarrier (such as paper, etc.) is passed between the rolls, lamination is effected and the coating is solidified. The squeeze roll on the plastic face is usually water-cooled and metallic, whereas the backup roll is generally rubber-surfaced and mounted with an adjustable pressure mechanism (see Fig. 1).

H. A. ARBIT, Development Laboratories, Bakelite Co., a Division of Union Carbide & Carbon Corp., Bound Brook, N. J.

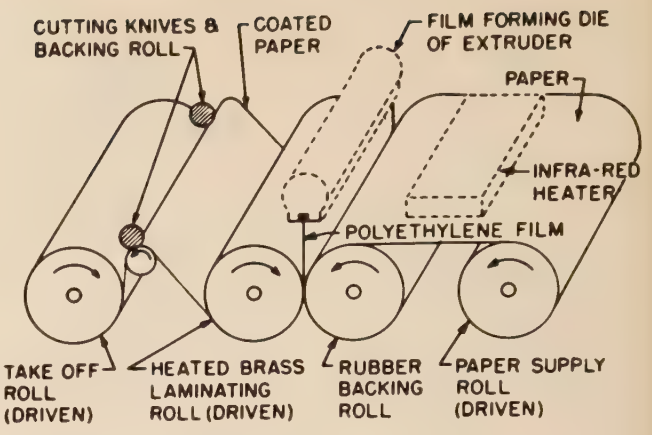

Fig. 1. Schematic diagram; extrusion-lamination of polyethylene film to paper

In developing this topic, some of the more important factors which affect the production of satisfactory polyethylene extrusion-laminates shall be discussed. The subjects considered are polyethylene resin grades, types of subcarrier or base, extrusion conditions, equipment design, and a recent development, paper post-heating.

RESIN GRADES

Of the various commercial grades of polyethylene resin supplied by Bakelite Co., those of most interest in this discussion range in approximate molecular weights from 12,000 to 23,000. The lower molecular weight resins have a correspondingly lower melt viscosity which in paper lamination affords easier flow of the molten resin into the fibers of the paper resulting in better adhesion. The higher molecular weight resins yield films characterized by greater toughness and strength.

Typical properties of unmodified, extruded, polyethylene resins generally used as commercial coatings are shown in Table I. The range of clarity and blocking characteristics shown allows the choice of the right coating for a specific application. Thus, for polyethylene-cellophane laminates, high transparency would be the prime consideration whereas with opaque subcarriers such as foil, transparency would be less important than blocking tendency. As illustrated by the table, these properties are inversely related to each other since both are a function of the surface roughness of the polyethylene coating.

SUBCARRIERS

The type of subcarrier used and the preprocessing or conditioning it is subjected to prior to lamination are of importance in obtaining satisfactory polyethylene laminates. In paper coating the supercalendered, glossy stocks offer greater resistance to good adhesion than, say, a rough kraft paper. In some cases, it is desirable to preheat the paper to improve adhesion. This prevents premature chilling of the coating and allows deeper penetration into the stock. The preheating is carried out as close to the point of lamination as possible and on the paper side to be coated so that blistering does not result from the evolved moisture. Preheating is less effective than postheating which will be discussed later.

Table I. Properties of Extruded Polyethylene Films

Resin designation.....	DYNF-3	DE-2300	DE-2301
		Natural	Natural
Degree of processing...	None	Normal	Intensive
Clarity and gloss.....	Poor	Good	Excellent
Blocking tendency.....	Low	Medium	High

Table II. Recommended Compound Temperatures for Polyethylene Extrusion-Lamination Linear Die

Resin	*Melt index, g./10 mm. at 190°C.*[a]	*Compound temperature, °F.*
DE-2300 natural	3.9–2.3	490–540
DE-2400 natural	2.5–1.3	530–580
DE-2500 natural	1.0–0.5	570–620

[a] ASTM D 1238–52 T, values for base resin.

In the extrusion-lamination of metallic foils the relatively nonporous, inert surfaces encountered accentuate the problem of adhesion. Recent work on related coating problems indicates that preheating the foil to about 450°F. oxidizes the surface sufficiently to bond the polyethylene. In any event oxidation of the foil is preferable to oxidative degradation of the polyethylene by thermal abuse since the latter often yields other undesirable effects which will be discussed later. Mention should be made here of the necessity of using completely degreased foil in order to eliminate contaminants which would impair adhesion.

Polyethylene-cellophane laminates prepared without adhesives or solvents require certain grades of cellophane for satisfactory bonding. Recent development work has shown that not all types of cellophane are suitable for this application. Under proper extrusion conditions, principally high compound temperature, generally good adhesion is obtained when the polyethylene is directly laminated to the wettable or untreated side of an MSAT-80 type of cellophane.

EXTRUSION CONDITIONS

The exact extrusion conditions required for optimum quality and yield of polyethylene for coating various subcarriers depend on the type, size, and throughput rate of the extruder. However, several general principles to be followed can be outlined.

Resin or compound temperature is probably the most critical factor affecting adhesion in all types of extrusion-lamination. Die temperatures alone are meaningless since the thermal history of the polyethylene is dependent on the throughput rate. Thus, at very high extruder speeds where the dwell time in the extruder is short, compound temperatures as high as 600°F. have been successfully employed for the average grade of polyethylene. Figure 2 illustrates the effect of output rate on the compound temperature for one set of operating conditions.

Recommended compound temperatures for extrusion-lamination of polyethylene are given in Table II. These compound temperatures are higher than those used for unsupported film in order to improve the adhesion. The use of higher extrusion temperatures is usually not advisable because of the additional thermal degradation of the polymer. Rheological and spectrographic studies indicate that at the extrusion temperatures shown degradation of polyethylene is complicated by the interaction of both thermal and oxidative effects. The increase in oxygen content and unsaturated groups with increasing compound temperature is indicative of the changes in chemical structure of the resin due to thermal abuse. Lengthening exposure times at elevated temperatures will, of course, degrade the resin further. The polarity associated with the formation of these oxygenated groups and unsaturated linkages is undoubtedly one of the reasons for the observed improvement in adhesion, as is the reduced viscosity. Table III lists some of the effects of incorrect

Table III. Effects of Incorrect Compound Temperatures

Too high	Too low
Degraded physical properties	Poor hot stretch
Excessive gloss	Nerviness
Tackiness	Poor clarity
Odor development	High strain

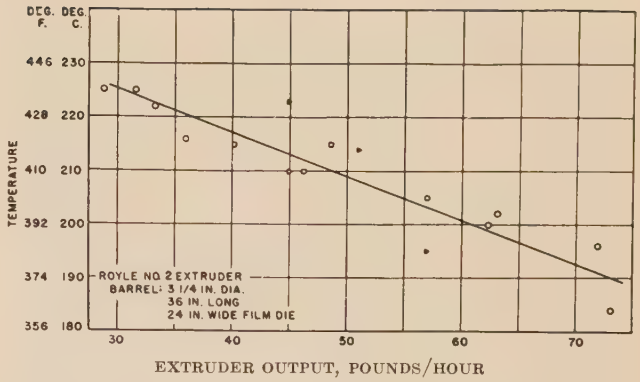

Fig. 2. Extrusion of polyethylene; effect of output rate variation on compound temperature; other extrusion conditions held constant

compound temperature, either too high or too low, on the polyethylene coating.

EQUIPMENT

The design and operation of the extrusion and laminating equipment should be considered from the standpoint of heat-transfer characteristics. The trend toward the design of V-shaped dies is caused by the necessity of maintaining a high compound temperature up to the point of lamination. With thin films the heat loss between the die lips and the bite of the pressure rolls becomes critical. The shorter the hot stretching distance, the more heat is retained and the more fluid the compound, thereby aiding adhesion.

The laminating roll is usually operated between 75 to 140°F. depending on the output rate and the physical properties desired. At higher temperatures the polyethylene sticks to or tends to follow this roll resulting in delamination. This poor release can be alleviated by the use of specially coated rolls, i.e., a Teflon-coated roll was found to be satisfactory in laboratory work. The effect of the cooling or quenching rate on certain physical characteristics of the polyethylene coating is indicated in Table IV. Pressure does not appear to be as critical as temperature in regard to adhesion and usually ranges from 75 to 200 lb. per linear in. of contact, with 100 lb. per in. being common.

POSTHEATING

Postheating of polyethylene-paper laminates is the next topic for consideration. Occasionally, the adhesion of thin polyethylene coatings to paper as produced by the extrusion-lamination technique is considered unsatisfactory. It has been discovered that a poorly adhering coating can be greatly improved by passing it through a heating zone. The degree of adhesion of such coatings can be controlled by adjusting the temperature of the heating zone and by varying the length of time the coated paper is in this zone. This treatment is not dependent upon any pressure and requires only cooling prior to wind-up.

The difficulty of controlling the degree of adhesion arises from two opposing requirements in the paper coating operation: the film must be applied hot to force it into the fibers, and the metal laminating roll must be cool enough to prevent the polyethylene from sticking to the roll and to solidify the

Table IV. Effect of Increasing Film Quenching Temperature from 20 to 90°C.

Higher stiffness
Higher tensile
Better gage control
Increased haze
Decreased blocking

coating. Preheating the paper enhances adhesion to a limited extent. The effect of postheating laminates which have at least a primary bond is always in the direction of improved bonding. It is believed that postheating causes the coating to shrink slightly drawing itself into closer contact with the paper fibers. Prolonged heating actually allows the coating to sink into the contours of the paper surface and be absorbed to some extent.

In order to test the commercial feasibility of such a heat-treating process a roll of polyethylene-coated paper was prepared at Bakelite Co.'s development laboratories by extruding a 0.6-mil film of 24 in. in width and directly laminating it to the paper. The coating was later exposed to a bank of radiant heaters at a speed of 250 f.p.m. The coated stock before heat exposure was unsatisfactory in adhesion, i.e., the polyethylene coating did not adhere to the paper with good strength and could easily be stripped. After the heat exposure the coating exhibited greatly improved adhesion and could not be stripped from the paper without tearing the paper surface fibers.

Polyethylene laminates have opened up the door to a wide range of versatile and unique packaging applications. The extrusion-lamination technique has aroused a steadily growing interest due to its desirable features of economy and one-step operation. It is hoped that the foregoing remarks have served to consolidate and enlarge interest in this relatively new method of coating with polyethylene.

CHAIRMAN: Thank you! Are there any questions on this paper?

MR. DREIS: You mentioned a half-mil film. What does that mean in pounds per ream or thousand square feet?

MR. ARBIT: I believe in terms of unmodified polyethylene, a 1-mil film is about 7 lb. per ream.

MR. DREIS: Are thicknesses lower than half a mil ineffective?

MR. ARBIT: No. They would be very desirable, but it is usually very difficult—depending on the resin grade used. There are resins that draw down below half a mil.

MR. LINDQUIST (U. S. Envelope Co.): In laminating cellophane, what other grades of cellophane, besides MSAT-80, would you consider satisfactory?

MR. ARBIT: We have not gone through the evaluation of all cellophane presently available on the market. We have worked with a limited grade and found that one particularly desirable, partly because of its waterproofing feature. Other grades, I am sure, would work equally well if they are similar in type to MSAT-80.

QUESTION: What machine speeds can be attained in operating on 16-pt. paperboard with polyethylene?

MR. ARBIT: I am afraid I can't answer that. We have not had too much experience in board lamination, but from what has been shown in literature, I would say the speeds can be high—up to 400 f.p.m.

MR. KENAN (St. Regis Paper Co.): Have you found any effect of postheating the cellophane that was beneficial?

MR. ARBIT: Postheating of cellophane laminates probably does not improve the adhesion. We have found the adhesion obtained by direct lamination is sufficient for the applications in which it is used. That is a point I would like to emphasize. Many times you do not want maximum adhesion. In fact, maximum adhesion can be detrimental in some cases.

MR. SLOATMAN (American Cyanamid Co.): Could you tell a little more about postheating material? Do you heat the material with hot air? Do you use a hot roll or do you apply pressure? Do you cool it afterward, and how?

MR. ARBIT: As I mentioned in my remarks, it requires no pressure whatsoever, but it does require cooling before you wind up. As to the way heat is introduced, it can be done by any commercially available type of system. However, it has to be applied on the polyethylene side—the coating side—so moisture does not cause blistering. A gas flame—depending on the speed of operation—might do the job. In general, in the work we have done, it has been with radiant type heaters.

CHAIRMAN: If there are no further questions, I should like to thank Mr. Arbit very much indeed for his excellent paper.

The last formal paper in the session is to be given by Mr. Hayes of the Noble and Wood Co., "The Forming Machine on Monolithic Sheet Production."

The Forming Machine on Monolithic Sheet Production

FRANK HAYES and F. CARLTON LOEBER

THE purpose of this paper is to introduce the forming machine publicly for the first time and to speak primarily of its adaptability to that segment of the plastics industry which has for its objective the combining of resins with various fibers or solids and the eventual solidifying of those combined ingredients under varying pressures and temperatures.

It seems proper that we should begin by explaining the origin of the forming machine design and its adaptation to monolithic sheet products.

The idea of the forming machine was originated in 1947 by Alvan D. Simpson of Plainfield, N. J. Mr. Simpson has devoted most of his life efforts in various capacities to the production and utilization of cement-asbestos products. His studies of forming methods employed in that industry convinced him that a more economical and more efficient method could be devised than that of forming a thin layer on a conventional cylinder mold and plying those thin layers on an accumulator roll until the required thickness was obtained, to be then cut off as an individual sheet and processed in various ways to remove excess moisture. He conceived the idea of reversing the usual methods of sheet formation and water removal by vacuum and suction by employing the use of compressed air for both forming and water removal in a continuous operation. He experimented with a handsheet model until he was satisfied that the principle was sound and then proceeded to construct a semicommercial size model on which a continuous sheet could be formed. That model has a forming cylinder 48-in. diam. with 6-in. wire face and is now installed at Bound Brook, N. J., where repeated check tests were conducted and the practical application of the principle of continuous formation and water removal by the application of compressed air was proved without question. Arrangements were then made with The Noble & Wood Machine Co. of Hoosick Falls, N. Y., to construct a commercial size unit and install it in their experimental section.

That forming machine has a forming cylinder 60 in. in diam. with a 36-in. wire face. It has been operated at frequent intervals during the past several months on numerous types of fibers and solids and combinations of both. Results obtained from the 48-in. diam. 6-in. wire face model at Bound Brook have been duplicated with satisfactory exactness on the larger unit and some of the product has been commercially tested with remarkably good results.

A cross section of the commercial size unit as it is installed at Hoosick Falls is shown in Fig. 1. It will be seen that the design embodies a forming cylinder enclosed in an air-tight casing. The cylinder is constructed with side rings which have polished surfaces on their outer circumferences and on

FRANK HAYES, Noble & Wood Machine Co., Hoosick Falls, N. Y., and F. CARLTON LOEBER, Forming Machine Co. of America, Inc., Bound Brook, N. J.

each side of the cylinder rim face. These are the sealing surfaces.

Rubber exit and entrance rolls are fitted between the cylinder side rings to provide an exposed area through which the formed sheet can be removed and necessary wire cleaning accomplished. The roll ends are expandable and are drawn to a tight seal fit against the cylinder side rings when the machine is operating. A cleverly designed rubber seal unit completely encloses the area between the exit and entrance rolls and across the faces of those rolls. A similar seal closes the sides of the cylinder and leaves the ends open for free water discharge. The whole interior of the cylinder is open to atmosphere.

At the start of operation the exit and entrance roll ends are expanded to contact with the cylinder side rings. Air is forced into the rubber seal members to bring them in contact with the surfaces of the rotating members. The material to be formed is pumped into the forming chamber and when the desired mix level is reached, the machine is started and compressed air is forced into the enclosure. The combined pressures of the feed pump forcing the mix into the chamber and of the compressed air within the chamber cause the fluid mix to seek an escape exit. The only exit available is the wire mesh covering on the forming cylinder. The greatest pressure area is that immediately after the entrance seal roll and as a result, the fluid mass rushes to the wire at that point and the fibers or solids contained in the fluid are deposited on the wire face. The mat formed on the wire provides its own filterable seal so that within one full revolution of the cylinder, the air pressure can be built up within the enclosure to a point corresponding with the porosity of the mat being formed. The enclosure is constructed to contain pressures up to 80 p.s.i.

When the formed mat leaves the solution area, it must pass through the area of air compression to the exit roll. That compressed air acts as a press against the moving mat and forces free water from it through the wire. Some of the air will filter through the mat as long as there is some porosity and it will carry free water with it.

The roll shown on the figure just above the solution level is a smoothing roll whose function is to level off the surface of the formed mat and avoid excessive air leakage through the mat.

It is readily understandable that the incoming solution must be pumped at pressures at least equivalent to the air pressure within the enclosure and that the exit and entrance seal rolls must be held at pressures in excess of the internal pressures to avoid air or solution leakage past those rolls.

After the practicability of this principle was proved for the forming of asbestos-cement products, experiments were conducted for the pulp and paper industry for washing of kraft pulps and for the forming and drying of kraft, sulphite, groundwood, linters, shredded bark, and various other fiber types.

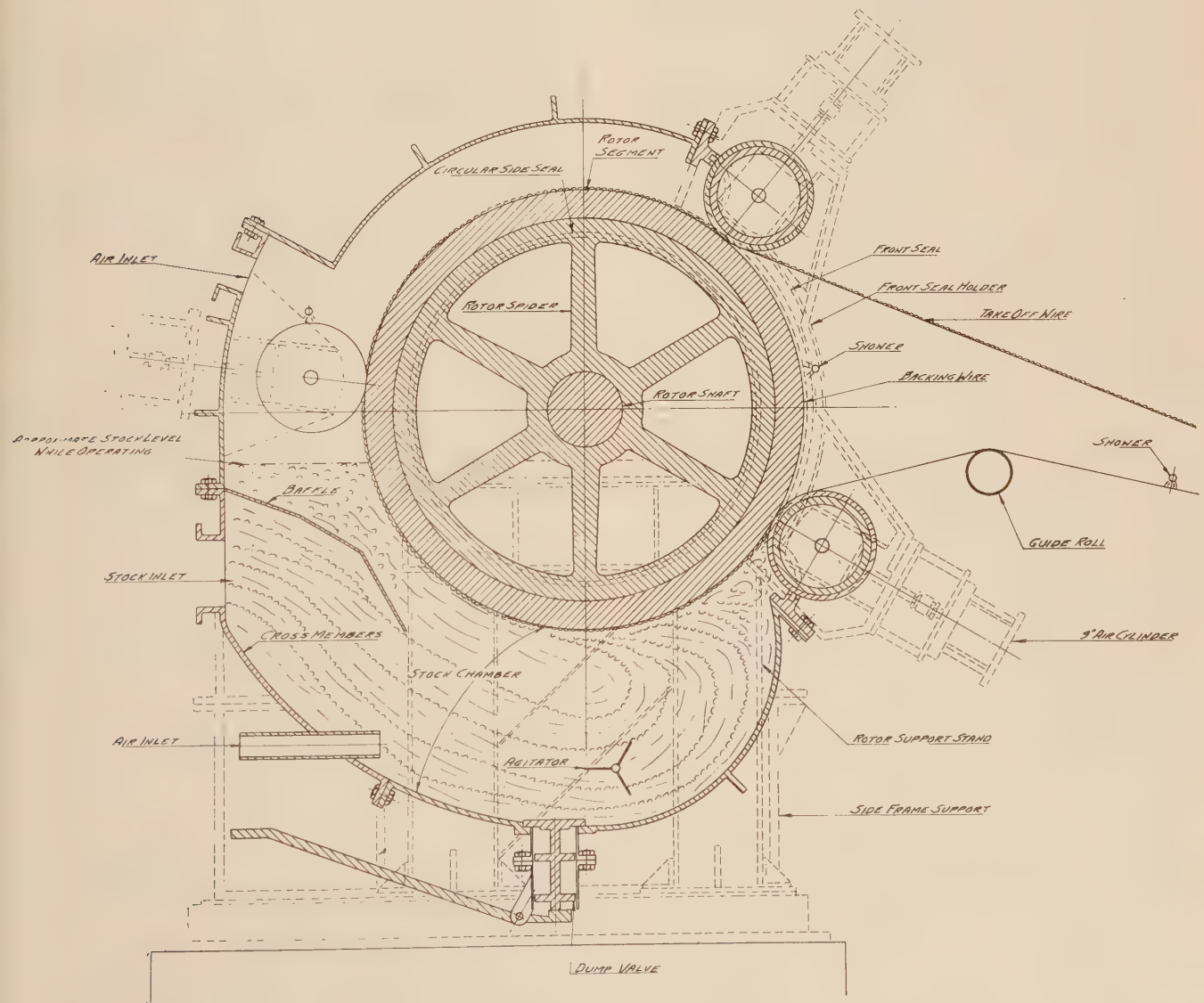

Fig. 1. Cross section of the forming machine

Fig. 2. Photograph of the installation at Hoosick Falls

These experiments were so successful and the effluent was so clear from even the finest fiber mixes, indicating a highly efficient filter result, that the possibilities of adding powdered resins directly into the fibrous solution were investigated and it was found that a very satisfactory material could be produced by using various fibers combined with phenols, vinyls, or any resins that were not soluble in water and could be held in suspension with the fibers.

The sheets formed in this manner come off the end of the machine installation at from 50 to 80% moisture-free solids depending on the freeness or filterability of the fibers involved. By varying the consistency of the furnish, the speed of rotation of the forming cylinder, or the pressure of air used in forming, continuous sheets can be produced in a wide range of thickness.

Inasmuch as the formation is obtained under pounds per square inch pressure, a very uniform thickness and density can be maintained without regard to the width of the forming wire so long as the governing factors remain constant.

The formed sheets are dried and can be pressed as desired, either as a monolithic sheet or they can be laminated into any thickness without the addition of any supplementary adhesives.

Sheets can be roll coated with colored resins or aluminum powder before final drying or decorative melamine paper or natural plywood can be used in making the finished sheets.

Experiments have been conducted using phenolic resins combined with all types of paper fibers, including waste news combined with paper mill effluents or sludge.

Paper pulps have been combined with asbestos and fibreglas and combinations of asbestos and fibreglas have been successfully used without the addition of paper fibers. Other fibers have been successfully used in various combinations such as bagasse, cork, leather findings, balsa wood, and kapoc. All of these combinations have been used with vinyl and polyethylene resins.

It is worthy of note that when using asbestos in combination with other fibers, nothing of a better grade than 6^D and 7^D asbestos has been used.

Experiments are now in progress using emulsions of polyesters and results so far have indicated that the forming machine will successfully handle this material.

Machine patents are held by The Forming Machine Co. of America, Inc. with offices in Bound Brook, N. J. They maintain a small pilot plant in Bound Brook. That pilot plant is equipped with a small hand sheet unit in which determining tests may be made with very small quantities of material. It is also equipped with the semicommercial model previously mentioned. That machine has a 6-in. screen face and can be satisfactorily operated on a continuous sheet basis from a furnish of 750 gal. of fluid with proportionate quantities of solids.

Results obtained from the hand sheet model are plotted in direct relation to those which may be expected from the 6-in. face continuous unit and, for the purpose of continuing tests on a commercial basis, the 36-in. wire face machine at Hoosick Falls, N. Y., will perform in direct relation to the 6-in. face model. The larger machine can be successfully tested from 2000 gal. of mix and provision is made for storage of mix up to 3800 gal.

Both The Forming Machine Co. in Bound Brook and Noble & Wood Machine Co. in Hoosick Falls will be very glad to arrange for any tests in which you may be interested, ranging from handsheet or semicommercial volume at Bound Brook to commercial volume in Hoosick Falls. The only requirements are that the necessary materials be furnished.

CHAIRMAN: Thank you, Mr. Hayes. I believe Mr. Loeber is in the audience and will answer any questions that may be asked about this equipment.

MR. SPENCER: Has all this work been done on the water phase only?

MR. LOEBER: No, we have recently made some tests on emulsions.

MR. SPENCER: Using solvents?

MR. LOEBER: Using solvents and liquid resins but it is still in the highly experimental stage.

QUESTION: What about a single weight sheet?

MR. LOEBER: We have run various thicknesses of sheet up to $1^3/_8$ in. That depends somewhat on the fibers being used and freeness and ability to flow under given pressures.

MR. BOOTH: Can you tell me the speeds that are obtainable?

MR. LOEBER: We have three distinct controls governing the thickness of the sheet you want to form. One of those is speed. The machine is geared to operate between 35 to 350 f.p.m., depending on the sheet required and the points which use the minimum amount of air pressure.

QUESTION: Would you say anything about the two dimensional characteristics of the sheet?

MR. LOEBER: You mean control on thickness across the face of the machine?

QUESTION: No. I am thinking of tensile.

MR. LOEBER: The material coming off the machine varies with the type of fiber you are using. Pure glass fiber has little strength and the addition of a small percentage of asbestos fiber gives quite a high strength. It goes down the line the same as where you have weaker paper with groundwood and stronger with kraft or sulphate.

QUESTION: Do you have comparisons with other machines?

MR. LOEBER: I think it is about the same as the normal cylinder machine except we do not get a machine weakness in the direction of the flow of the fiber. We force the fibers in place with pressure against the screen.

QUESTION: You said the web came off at what? I didn't catch it.

MR. LOEBER: Fifty to eighty per cent varying with the type of fiber. That is before any drying.

MR. BOOTH: Do you have trouble keeping the screen clean using 80-lb. pressure?

MR. LOEBER: No. It requires special handling in washing. We wash with a double row of jet cleaning devices at about 80 lb. pressure and with that we have no trouble cleaning them from the inside out.

MR. BOOTH: What about the mesh of the wire? Does it have to be changed?

MR. LOEBER: Yes—to a certain extent. We have operated from 30 up to 100 mesh for various products.

CHAIRMAN: If there are no further questions on this paper, this will conclude the formal papers of the day's session.

I should like to take this opportunity to thank all of the speakers today for the time and effort they put forth in getting together these excellent papers.

Beater Addition of Resins

The last item on the program will be a panel discussion on a very interesting topic—"Beater Addition of Resins"—and I am going to ask the six members of the panel to kindly come up here to the stage.

Each of the panel members will speak very briefly on the specific problems and, after that, the meeting will be open to questions from the audience and audience participation. I would like to have you regard it as a round-table affair.

The first talk will be given by John Baymiller of the Armstrong Cork Co., who will talk on a suggested mechanism for beater addition.

JOHN BAYMILLER: During the last 6 or 7 years there has been considerable interest and activity in beater saturation or beater addition due, probably, to the great number of materials that have been developed by the various manufacturers. You all, I think, know pretty well what those materials are in the line of synthetic rubbers, copolymers, and various kinds of resins which are all available in the form of emulsions or latices that can be used in the beater addition process.

Conceivably, any of the wide variety of materials can be combined with any fibers in any proportions so as to yield a wide variety of materials having very interesting properties. But, generally speaking, the processes that have been described for the beater saturation operations have been more or less empirical in nature and have described steps and results. They have not gone very far into the fundamental mechanism of just how the fiber and binder are combined.

It must be certain that there is a fundamental mechanism connected with the behavior of these materials and the combination of these various binders and fibers and, if we know what that f ndamental mechanism was, it would greatly assist both the people developing products and the manufacturers of raw materials so that they could develop raw materials tailor-made for the process.

So, what I'd like to do here this afternoon is suggest a mechanism—give you a picture of what that mechanism might be—showing the combination of the binders in a water suspension and the fibers.

I think it is pretty well accepted that the stability of hydrophobic suspensions, which is what we have in these systems, is dependent on the electrokinetic or zeta potential.

Assume the blackboard is a tank of water and in it you have a fiber suspended. With that fiber you have a lot of particles of latex or other suspension mixed together. As soon as this fiber is put in water, according to all the theories, there is an adsorption of hydroxyl ions from the water, setting up a layer of negative charges adjacent to the fiber. You will also have a layer of positive charges, and this layer extends out for some distance from the fiber, setting up a potential across this layer between the fiber and the outer reaches of the positive ions. That is called the electrokinetic, or zeta potential.

You also have the same thing occurring on the particles of the suspended binder. As long as that zeta potential or electric double layer, as it is called, exists; or, as long as it is thick enough, you have a condition of stability. As long as the layer is in contact with the fiber, or the suspended binder, you have a condition of stability that will prevent any deposition of the binder of the fiber. So, our problem becomes one of adjusting, or destroying this electro kinetic, or zeta potential, on both the binder and the fiber so that when the two come together, other forces will come into play and the particles will stick to the fiber.

If we treat the fibers to destroy only that electro kinetic potential, but not that on the binder, you can see the binder will still remain as a stable suspension.

If you destroy only the layer on the particle, the particle would be in a condition to stick to something. But it will not stick to the fiber because its protective layer would still be there to prevent adhesion.

Now, if we destroy it on both of them, you can see the fiber would be in a receptive condition to take on the binder particles; but the binder particles would also be in a condition to accept each other and you would get precipitation or coagulation of the binder particles on each other—some on the fiber, but most on themselves.

I don't know whether you can see this picture, but it will be evident we have large gobs of binder here, and the fibers are bare and uncovered. In this case—one of the synthetic rubbers—we believe the particles of the binder coagulated on themselves, resulting in large agglomerations which left a lot of bare fibers and gave poor quality in the finished sheet.

So the problem becomes one of treating the fibers and particles of the binder suspension with something to reduce their protective zeta potentials so that the two will go together and the particles of the binder will not precipitate on themselves. That is a cute trick if you can do it. Generally speaking—and this can be found in most literature on the subject—the method of adjusting the zeta potential of a suspension such as this, is by treating the suspension with electrolytes. So, we have the problem of adjusting the fibers first and then the particles to that critical potential which will allow the particles to stick to the fibers and not to themselves.

CHAIRMAN: Thank you, Mr. Baymiller.

Our next speaker will be Mr. Ramage, of Latex Fiber Industries, Inc., who will talk to you on some of his laboratory experiments.

FRED RAMAGE: My work is primarily concerned with elastomers. So, for some of you who are more interested in resins—for your sake—I will try to be more brief.

Beater addition of resins is not new in the light of resin and asphalt sizes or gums to improve formation—but with the advent of wet-strength additives, an awakened promotion in all sorts of goos and gunks has occurred. Thermosetting, thermoplastic, elastomeric, and resinous materials are all currently being used to develop a wide variety of properties in the finished sheet.

For high-strength papers for the artificial leather field, either kraft or rags are generally used because the long fibers give good strength themselves and, therefore, give still greater strength when treated with a binder. Other fibers are not excluded however, for certain additives can upgrade even old news for such products as stiffeners or hardboards.

The additives, in emulsified or in water-miscible form, are practically always added at the end of the beating cycle. The prepared stock may be first diluted, then treated with fillers, antioxidants, plasticizers, extenders, and stabilizers as the case may demand. Most emulsions withstand infinite dilution without breaking out but wherever sensitivity is encountered, either the emulsion or the stock, can be treated with various protectives, such as rosin or tall oil soaps, proteins, or alkalies, to insure comparable pH conditions of the stock and the additives. In some cases the emulsion can be reduced in pH to that of the stock before addition. This generally agglomerates the emulsion particles and reduces white water losses. After the emulsion has been mixed into the fibers, precipitation can be accomplished by reducing the pH further with the aid of an acid or a salt.

Some treated stocks required certain temperature limits to control tackiness of the binder, either to effect a bond to the fiber on one hand, or to prevent plugging of felts or wires on the other.

Laboratory handsheets show the result of adding to the beater such binders as natural rubber, GR-S, neoprene, perbunnan, polyvinyl acetate, polystyrene, polyvinylidene chloride, and acrylic resins. Retention of the polymer can be determined by extractions or by analysis in some cases. However, it is advisable to use savealls and a closed system to recover the white water losses in any case.

The foregoing has been confined to alkaline emulsions. Acid emulsions are also available which, in theory, should have an advantage of better bonding to the negatively charged cellulose fiber. It is our general experience that, although retention of the polymer is good, very little strength is obtained.

From this it might be assumed that the polymer particle is too small and too widely spread to be beneficial. There may be an optimum particle size for beater addition work.

Products made by Latex Fiber industries are all of the flexible, high strength type, used primarily for artificial leathers in the form of industrial catalog covers and bookbinding, and in smaller amounts for shoe products and automotive gaskets.

CHAIRMAN: Thank you. The next speaker will tell us something about the addition of various rubber latices to pulp stock. Robert H. Walsh of the du Pont Co.

ROBERT H. WALSH: Elasticized or rubberized papers are as intriguing a concept today as they were in 1924 when Kaye was credited with the first addition of rubber to pulp at beater. At that time, rubber alone was available as a possible additive and not even rubber of the quality known today. Natural rubber is still one of the contenders in the field of beater additives as a cellulose binder, but is taking second place to its grandchildren, the synthetic elastomers. Today, there are three major classes of synthetic rubbers: the so-called butadiene styrene polymers, designated as GR-S; the GR-N types which are butadiene acrylonitriles, commonly known as Hycar, Chemigum, and Paracrils; and the third class being based on chloroprene or neoprene.

Each of the synthetic elastomers is characterized by its own group of physical properties. GR-S producing a gum stock of relatively low physical properties, which, however, can be compounded with carbon blacks to produce compounds suitable for tire treads and other mechanical goods. Acrylonitrile polymers are known for their oil resistance and overall good physical properties. Neoprene is known for its oil resistance, flame retarding properties, ozone, and sunlight resistance.

In paper, butadiene styrene latices have found two types of markets. The high styrene polymers are used as paper coating binders and the so-called low styrene level polymers, 50–50 or 60–40 ratios, finding a place in the high percentage beater addition fields for use in the preparation of imitation leathers or in sole papers where a sheet with a draggy tear is most important. Butadiene acrylonitrile polymers have found a place where oil resistance and high elongation properties are important. One such field is gasketing materials. In these applications 20 to 50% elastomer are employed. With neoprene there are two fields of activity in wet-end applications, so-called low percentage and high percentage additions. In the low percentage range, that is from 0.5 to 5%, the place filled by neoprene is rather unique. The very small percentages give outstanding wet-strength increases in impact strength, smoothness, internal bond, and a high degree of resistance to dilute acids and bases. In the high percentage field, it produces a high tensile strength sheet with good tear, high modulus, good edge tear characteristics, high internal bond, and good oil resistance. This makes it of interest in sandpaper backing, masking tape, and most parts of the imitation leather field where relatively stiff stock with real body is desired.

Today, the concept of mixing the two long chain polymers is just in its infancy since, with the new polymerization techniques now being developed, both elastomer and cellulose can be tailor-made to add the desired properties to the new hybrid.

CHAIRMAN: Now, we are going to have Mr. Howells of The Institute of Paper Chemistry tell of the addition of phenolics.

T. A. HOWELLS: Several years ago we had occasion to work with a number of beater additive phenolic resins and we evaluated a number of their properties for the industrial use of interest at the moment. Our special interest was in retention. We had had good reports from commercial runs about the high retention obtained, and in the laboratory work which we did it seemed from the appearance of the white water that we were getting good retention. However, one of our problems was to determine retention on the sheet in a manner a mill might use as a control test. We went through a number of procedures using extraction and various other techniques. To our surprise we found the best retention we seemed to get was in the order of 65 to 70% of the resin we were putting into our system.

One of the problems in laboratory work of this sort is simulating commercial conditions. If you try to retain clay, for example, in the laboratory sheet, you don't get the same retention you do in the commercial operation because of the chance in the latter to recirculate the material and operate under different consistencies and forming conditions. So, we recognized our results might be low for that reason.

We found, as you might suspect, in using a range of different materials and conditions of use, that we had a considerable range of performance, but the products that gave the best results showed a rather high loss to the white water in soluble form. We had other materials more insoluble in themselves but when we cut down on the soluble loss, we tended to increase the loss of suspended material. The soluble loss was 20 to 30% of the resin itself. Subsequently, we prepared a number of different resins ourselves and were able to obtain results comparable to the best of the commercial resins but we had the same problem with soluble loss.

This is an example of one very specific application but I would like to use it as a warning to consider possible stream pollution in connection with beater addition. This case gives you a nice chance to do a little calculating. According to the United States Public Health Service, the recommended standard for drinking water specifies a maximum content of phenolic compounds of one-thousandth part per million. If you have a mill location on a stream with a flow of 2000 cu. ft. per sec.—and a lot of paper mills don't have that much flow—then it is easy to calculate that, in order to keep the concentration of phenolic material in the water downstream from the mill to the level, it means you are limited to a loss to your effluent of about 12 lb. of phenolic material a day. A mill using 1% of resin in 60 tons of production would have to operate at 99% efficiency and lose only 1% to the effluent from the mill. On the other hand, with a small, trial run of 5 tons where you add a high percentage of resin (50%), to keep your loss for the day to that level, you have to have a retention of 99.8%.

As I mentioned before, this is an extreme case because phenols—particularly phenols after they are chlorinated in a water treatment system—are very easy to detect in the water system. Other materials may not have the same problem of solubility and there may be cases where even chlorinated phenols will not be as critical because of the nature of the water supply. Likewise, the seriousness of the problem will vary with the different mills depending on how tight their white water system is. I mention it only as a phase of beater addition that might be overlooked

CHAIRMAN: Mr. Spencer of Knowlton Bros. might offer some comparisons on the results obtained by saturation versus resin addition.

HORACE SPENCER: I'd like to preface my remarks by saying I am neither a champion for saturation nor a champion of beater addition.

From early in the first century, when Ts'ai Lun first worked on a hand beaten mass to produce the forerunner of today's paper, to the present time, there has been great interest shown in beater additives.

It is reasonable to assume that when each new phase of beater additives was introduced, the enthusiasm ran high among the people introducing the products and the manufacturer trying to use the product for the first time. This is understandable because in order to invent and develop one must have the courage to wonder, ask, and act: to carry their thought to the end point, production. In order to do this one must be enthusiastic and optimistic.

The reaction of the introduction of rosin size to the beater must have been optimistic or else we would still be using gelatin for sizing. The introduction of rosin size must have given the paper manufacturer visions of new and better products along with better profits, and so it goes, for there is very little change in human nature.

To do a job better and at less cost is only human and to be a little overoptimistic concerning a process, to do this job, is also human.

When Bakeland obtained his patent on the beater addition of phenolic resin in the syrup, lump, or granular form, it was doubtful if a commercial product of value could be produced. That did not stop many people in the paper field and in the resin field from being interested in trying to produce a new and novel paper-plastic material. It would, therefore, follow that with the interest shown, by the producer of resins, and the papermaker, that optimism would run high when a resin was produced, at long last, in a syrup form that could be added to the beater by merely reducing the solids content of the syrup with water and adding the chemicals, common to most paper mills, to the pulp-resin slurry. An acceptable paper-plastic sheet could be made on the paper machine. From this point, overselling, due to overoptimism could, and no doubt did, happen. It was thought that we were embarking on a new era and that the days of the saturator were numbered. It was this feeling, expressed or implied, that has caused considerable controversy between the merits of a beater-treated sheet and a saturated sheet.

The thoughts were 50% right, we did and are entering a new era but the work of the saturator has not abated, but has progressed, and will continue to progress. There is little doubt that, when the first successful run of paper-plastic was made, the thinking of those concerned was primarily along the lines of economy. That, by the addition of resin to the beater, the additional step of saturating, to produce a paper-plastic sheet, would be eliminated thereby saving the costs of labor, power, equipment and the loss of the diluent and the waste of material. If this projection could have been borne out then, indeed, the highest hopes of the optimistic workers might have been realized.

But such was not the case. By analogy there is as much difference, or more, between the beater treated paper-plastic and the saturated paper-plastic as there is between a fourdriner and a cylinder-made piece of paper. Yet, each of these papers produced has a very large market and in most cases in a different field. This could hold true with the beater treated paper-plastic but it would necessitate the combined efforts of the sales department with research and development departments of both the resin producer and the paper manufacturer.

The possibilities are tremendous. The new fibers and new resins that have been introduced and those that are bound to come later, open the field to unlimited boundaries. This is true not only for the paper machine but for the saturator as well. It would behoove us to spend more time in research for the development of new products than to spend our time and energy in trying to prove that one process is better than another.

CHAIRMAN: We will now hear from Mr. Landes on resin addition experiences he has had in the laboratories of the American Cyanamid Co.

CHESTER G. LANDES: I wish that I could appear before you here today to tell you about a new resin and a new process that would increase the tensile, tearing, and bursting strength of paper; that would make it as strong as cloth and as tough as leather—a process where there would be no trouble with broke recovery and, at the extreme, the cost would be about $10 a ton. It is probably well that I do not come here with this objective becuse I don't think our company could supply enough resin and I am afraid what we could supply would be at a loss.

I would like to describe briefly some experiences in trials of a method for adding various thermoplastic resins and rubbers to paper by the method of beater addition. The coined name of the process is "Bardac"—beater addition resin dispersion—and the "ac" has to do with American Cyanamid.

This process, which I would like to describe briefly, consists in treating the pulp in the beater by several fairly simple steps.

First, it is necessary to have the pulp beaten and dispersed in water with a sulphate content of 50 to 75 p.p.m.

The second step would be to add between 1 and 5% of a melamine resin colloid—the same type of resin now used commonly for wet-strength treatment of paper.

After standing a short time at an ordinary pH of around 4 or 5, and with the melamine resin pretty well adsorbed on the fibers, it is then possible to add large proportions of many dispersions and emulsions of various thermoplastic materials and resins. However, these resins or dispersions must have a suitable emulsifying or dispersing agent present so that the resin will be deposited on the fiber satisfactorily. A wide variety of resins can be used all the way from wax through elastomers and rubbers up to some harder and more brittle materials such as polystyrene.

It is not hard to find an emulsifying agent that will give the proper deposition. Generally any of the anionic dispersing agents commonly used, work successfully in this process. Soaps are also used quite widely and with various adjustments these soap emulsions can be added very satisfactorily.

I don't know what the theory of the process is. Perhaps it fits in with Mr. Baymiller's theories, or maybe L. H. Wilson, who developed the process could tell us. But, it is known that the melamine resin deposited on the fiber gives it a positive charge and, from there on I'll let somebody else carry the ball.

What do we get when we deposit the resin on the fiber and make a sheet of paper? In trials so far we have been able to deposit from 5 to 150% of the various thermoplastic resin dispersions on the weight of fiber and we have investigated possibile uses of the sheet of paper containing such resin in various ways. For example, the addition of 10 to 20% of a latex—one of the common types—has given a tough leathery type of board that can be calendered or smoothed in various ways. The treatment of linoleum base felt has offered a possibility for various types of resin treatments. As you know, linoleum consists of a felt, a piece of saturating paper saturated with asphalt, serving as the base for the linoleum part of the assembly. There are various disadvantages of the asphalt impregnation and there is considerable promise for the treatment of the base felt with a small amount of latex to give it strength and other characteristics that are required.

Going into another type of resin—polystyrene—it has been possible to make sheets of paper containing up to equal or higher proportions of polystyrene, winding up on the paper

machine as a regular roll of paper but with a resin content such that a sheet subsequently can be pressed or laminated for making articles such as trays, dishes, etc.

Now, it is obvious there are a number of beater addition processes and I would be the last to claim any one would fill the bill for all applications. There are going to be lots of resins and lots of processes for putting resins into paper. This particular process seems to have some advantages that merit consideration.

In our experiences to date, the resin treated stock is very free and drains easily; good retentions can be secured on both cylinder and fourdrinier machines. No operating troubles have been apparent in the nature of sticking-up of the rolls and wires, which, of course, is one of the common drawbacks encountered many years ago; and the distribution of the resin through the sheet has given a sheet of paper that can be pressed and will have uniform properties.

Several of our speakers have mentioned words of caution and rightly so. In considering the future development of beater addition processes, it is obvious that much remains to be done. Despite any claims to ease of operation of the process, we all know it will take a lot of development work and technical control to make any process work satisfactorily.

New developments in resins are needed. You can't take any resin out of a catalog and get all the physical properties that might be required for a certain sheet. Probably the most important field where intense study is needed is in market research and sales development of paper containing resins.

It is rather easy to get an attractive looking sheet of paper but sometimes more difficult to find a market for it and the economics, of course, are very important in comparing the saturation and beater addition procedures.

I think it is obvious that the beater addition procedure, applied to a big machine, won't work unless you have a demand that justifies continuous operation of the paper-making unit for a considerable period of time and where the contacts and work with the final user of the paper have been such that you can make a profitable operation of it.

CHAIRMAN: You have heard the various speakers on the panel and their views on the phase of beater additions. I'd like to have you all regard the talks as a catalyst to spark the questions on the subject and not only will the members of the panel attempt to answer questions, we would also like to invite any member of the audience to contribute answers where they have an interest in the subject.

MR. EIRICH: Mr. Ramage made a statement that some things are necessary to provide a satisfactory union of the resin particle. He made a rather startling observation that if you bring the positive particles to the negative fibers, you get bad cohesion and eventually Mr. Landes turned the table around and said, if you make the fiber positive and particles negative, you get good adhesion. These are contrary statements and I would like to hear more about it from the panel.

MR. BAYMILLER: That question of "postive" and "negative" I think has been used in beater addition discussions quite a lot and rather loosely. I think—this is my own opinion — that many people have the picture of static positive charge attracting a static negative charge. I don't believe that is the way it works. As I explained, those positive or negative charges on the fibers or the particles suspended in water are not static charges. They are charges due to the zeta potential and due to the electric double layer on the fibers. That can be either positive or negative. A cellulose fiber, suspended in water, will be negative because the hydroxyl ions are absorbed on the surface and the positive ions—fewer of them —are out in the dispersion phase.

If we have a positive fiber, we have just the reverse. That layer, the absorbed layer, of either positive or negative ions is firmly fixed. It is immovable.

Now, in order to make this system work, as I described it earlier, you have to adjust the zeta potential so that the fiber or the particle is receptive to the other. The zeta potential does not have to be reduced to zero. There is a critical range where the depth of the layer becomes so thin that the van der Waal's forces come into play. So, when we talk of positive and negative, it is a relative thing and if we have a positive charged fiber, that layer can be so thick that a negative particle will still not adhere to this positively charged fiber because, although the positive charged particle will tend to neutralize the negative charges, the effect of mutual precipitation won't be strong enough to completely destroy the positive film and the result will be poor adhesion.

Now, in the case of Chet Landes' description of the positively charged fiber resulting from treatment with melamine, it seems to me his positively charged fiber represents half the picture. He may actually affect the zeta potential of the fiber by treatment with the melamine resin. The resulting electric double layer may not be adjusted just right for the proper receptive condition and the binder particles may not migrate and stick to the fiber as they would if there were no zeta potentials on either.

I think that is how it would tie together.

MR. LEVENSON (Reichhold Chemicals, Inc.): I'd like to ask Mr. Baymiller what induces the adsorption of ions on the fiber to create a positive zeta potential?

MR. BAYMILLER: That is a phenomenon that just occurs. Whenever cellulose fibers come in contact with water, you have the zeta potential created. That just happens. In the case of cellulose, I think the explanation is that the hydroxyl ions of water are more capillary attractive and they are the ones that preferentially adsorb on the cellulose. In the case of an aluminum compound where you have an ionogenic substance, there is a tendency for the aluminum to ionize. It puts out positive changes and that is why it is positive in water. There are other materials that are positive in charge—but they are relatively few—aluminum hydride, zinc oxide, ferric hydroxide, to mention some.

MR. LEVENSON: In the case of aluminum, due to ionization, there is a positive charge. In the case of the fiber, it is negative. Do you think there is any ionic charge on the fiber?

MR. BAYMILLER: Only insofar as this electric double layer is set up.

QUESTION: How do you incorporate your theory into the exchangeability of the ion of hydrogen?

MR. BAYMILLER: I don't believe I am in a position to answer that.

QUESTION: The fiber represents a charge of ions, does it not?

MR. BAYMILLER: That is right.

MR. ARLEDTER: To illustrate, you take a normal solution of acid or alkali and add 5 grams of cellulose, which is neutral, and the pH will go from 2 to 5 and from 11 it will go to 9 which means the cellulose fiber picks up any amount of acid.

MR. BAYMILLER: Isn't that an actual chemical reaction? This is not a chemical reaction but merely adsorption. The adsorbed ions do not remain on the fiber when treated with quantities of electrolytes. This potential will then be completely dissipated and won't exist.

MR. ARLEDTER: It is not clear whether it is chemical reaction or adsorption. I would say both take place. I do not believe it would be possible in low temperature range and with a low pH range.

MR. BAYMILLER: You get completely outside this mechanism in concentrations like that. These exist only at low concentration of ions. If you add just a little electrolyte, it destroys this zeta potential and other forces come into play.

QUESTION: I believe Armstrong has issued patents within the past 6 months or a year which had a bearing on that. Would that help to clarify that—to discuss those?

Mr. Baymiller: That was an entirely different problem. I did that work, by the way, and it was in connection with spinning rollers in textile mills and the adhesion of fibers to the roll coverings. It had to do with synthetic rubber and textile fibers. Some of these same principles were involved in that.

Question: Does the ionic theory apply to any fiber or only to cotton?

Mr. Baymiller: Any fiber. If anybody is interested in the theoretical background and some of the things I have discussed, I would recommend that they get hold of Abramson's book on electrokinetic phenomena; or Gortner's book on the outlines of biochemistry. It might help clarify these problems which you are dealing with largely in beater additions.

Question: How do you spell those?

Mr. Baymiller: H. A. Abramson and R. A. Gortner.

Question: What steps would you take to develop that zeta potential?

Mr. Baymiller: That is a good question. I am sorry I can't tell you specifically what to do. I can only say it can be adjusted by the proper use of electrolytes. In general, the univalent salts are very weak, for example, sodium chloride. Bivalent salts are a little stronger. Aluminum, being trivalent, of course, is about the best.

One of the reasons is because it brings the zeta potential down to zero in the case of cellulose very nicely and it stays there. Thorium salts with valence of four are stronger; in fact, too strong because the zeta potential comes to zero and then goes strongly positive, which would be as bad as strongly negative. I can't tell you how to adjust the zeta potential of the fiber and binder at the same time. At least, I can't tell you that today.

Mr. Johnson (Stevens & Thompson Co.): How can the zeta potential be measured?

Mr. Baymiller: There are a number of ways of doing it described in the books I mentioned. Suppose you have a U tube—this is the classical example—provided with electrodes plus and minus connected at the top with a source of current. Fill the U tube with distilled water. According to the theory, as soon as the water comes in contact with the glass, there will be a zeta potential set up along the glass walls. Apply the current and the water will rise on the positive side. To get this movement, the U tube must be of capillary dimension. When the column of water moves, you have electro-osmosis.

In the case of cellulose fibers, you can resort to making the U tube of larger dimensions and put a plug of fibers and then you can measure the rate of rise of water which indicates the magnitude of the zeta potentials of the cellulose fibers.

There are formulas that can be used to calculate it.

Mr. Arledter: Perhaps I have another interesting explanation for the retention of rosin flocculates in paper. If you flocculate a rosin emulsion, or a sodium resinate solution, with a salt—for instance, magnesium chloride or NaCl, the volume of your flocculate may, for instance, approach the magnitude of 1 cc. for a given amount of rosin. The particle size of the flocculate may be, in this case, in the range of 1 to 5 mu diameter. If you employ the same flocculating system in combination with a cellulose pulp, you may obtain a rosin retention of approximately 20%.

If you flocculate the same rosin milk with aluminum silicate, to give you the other extreme of the same flocculating system, you will obtain a volume for the flocculated rosin particles which is 22 times, or more, as big as the flocculate obtained with NaCl or $MgCl_2$. The retention for a rosin aluminum sulphate floculate is, under these conditions, 93%.

You can proceed to show that in both cases the rosin retention in the pulp is a function of a filtration phenomenon. You can prove this in checking the retention in a given system of inorganic filter particles with a diameter of 1 mu and particles with diameter of maybe 20 to 30 mu and you will find that again the retention for the 1 mu particle will be only 20%, while the retention for the 20 to 30 mu particles may be in the range of 80 to 90% under proper conditions.

My studies in this special field, which covered a period of more than 2 years, confirm that the theory of electrical charges applies excellently for special colloid systems with very small particles of maybe 0.5 to 1 mu, or less, but not to flocculating systems where big particles—say about 2 or 3 up to 30 mu are used. For the low particle range the electrostatic theories may apply while for flocculates with big particle seemingly a pure filtration retention system is mostly responsible for the retention of the rosin in the paper. The electric forces available are not big enough to hold or attract the particles to the fiber and the forces or turbulence will be in general much greater than the forces of adhesion. For very small particles the theory of absorption and adsorption will apply.

It is, in my opinion, a mistake to try to apply the electrostatic theory to all emulsions and flocculating systems because it can be easily shown with a normal lab microscope that the particles for most emulsion flocculates are not in the range that the electrostatic theory alone can possibly be helpful. In my opinion there should be made a clear-cut distinction between electrostatic theory for the low particle size and the filtration system for particle sizes which, in many cases, are found in practice.

As a matter of statistics it would be of interest to see how many per cent of all flocculation cases in paper mills can be explained by electrostatic forces and in how many cases the plain filtration retention system will apply. I would say that maybe up to 60 to 90% of most systems in paper mills can be explained by the filtration system and only 10 to 40% by electrostatic forces. The general belief seems to reverse these figures. It is, therefore, generally believed that 90% of the retention is due to electrostatic forces and maybe only 10% to filtration systems.

Mr. Baymiller: That is a good point. I neglected to mention particle size is an important factor. I think Mr. Ramage did mention it. It has been my experience that the particle size must be very small to get successful operations, particularly in the higher percentage of resins.

Mr. Ramage: I more or less brought up the point to get discussion on it to see what other people thought about optimum size for the best retention and best efficiency.

Mr. Arledter: In regard to the particle size, I want to mention some other interesting facts. According to my own experience, it is not only important to flocculate big enough particles for retention, but it is of infinite greater importance to obtain the most voluminous aggregates with the smallest amount of resins. If you flocculate rosin size solutions with $MgCl_2$ you will find that 1 gram of rosin is able

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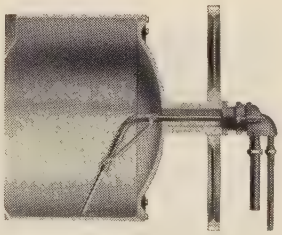

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MR. KING (National Starch Co.): Mr. Landes, can you say anything about the efficiency of different types of thermoplastic resins when they are added to the beater? Do some retain better than others? I am thinking of vinyl chloride, vinyl acetate, etc.

MR. LANDES: In processes such as the Bardac process, I would say there is no apparent difference in retention. That would be a function of using the right amount of melamine resin and using the right dispersing agent for the thermoplastic resin. The amount and type of emulsifying agent both are important. If you make a dispersion of vinyl acetate and use a large amount of dispersing agent, it is very difficult to get good retention. You get the best results by using a sufficient amount of emulsifying agent but not too much so that it overrides the effect of the melamine resin.

I think the theory of depositing these dispersions can be made pretty elaborate but to me it is just neutralization of the charges so the particles can get close together.

MR. KING: The type of resin would have little effect?

MR. LANDES: Unless it was a resin with chemically active groups.

QUESTION: Mr. Baymiller, is there any method of determining the zero point?

MR. BAYMILLER: This is a matter of critical potential. You wouldn't have to reduce them both to zero. Each system has its own pair of critical potentials at the point of precipitation.

MR. KHANDELWAL: Is there any method of determining that?

MR. BAYMILLER: Not that I know of—other than experimentation.

QUESTION: I wonder if, in the Bardac process, that point might not be the exact one for the best results?

MR. LANDES: I don't know, but I suspect it is not too far from that neutral point. One theory is that the melamine resin adsorbed on the fiber is able to adsorb further on its surface and, therefore, adsorbs some of the dispersing agent from the latex emulsion, destroying the separation between those particles and enabling them to get close to each other as well as close to the cellulose fiber.

QUESTION: I'd like to ask any member of the panel what resin systems have been used on beater additions to add those resins which impart rigidity without discoloration to the sheet?

MR. SPENCER: What is your base stock?

QUESTION: Groundwood.

MR. RAMAGE: Polystyrene would probably be the first consideration. There are several polystyrenes out that give a fairly rigid result without too high fusing temperature.

QUESTION: Do you use a water size with the melamines as part of the Bardac process?

MR. LANDES: Originally it is water and insoluble melamine resins. It is sort of a water dispersion of melamine resin in the form it is used.

QUESTION: Is that actually a solution or a colloidal suspension in acid?

MR. LANDES: Well, I think the particles figure to be in the neighborhood of 500 A units maximum size and that is on the border between colloidal suspension and true solution. It is much smaller than for latex or similar dispersions. It is almost a solution, let's say.

CHAIRMAN: Any further questions? If not, this will bring our meeting to a close and I would like to take this opportunity to thank the members of the panel for the effort they have gone to on these thought-provoking topics on the subject of beater additions.

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Calendar of TAPPI Meetings

NATIONAL MEETINGS

Fundamental Research Conference on the Fundamentals of the Paper Machine, Appleton, Wis., September 21–24, 1954.

Eighth Alkaline Pulping Conference, Dinkler-Tutwiler Hotel, Birmingham, Ala., October 6–8, 1954.

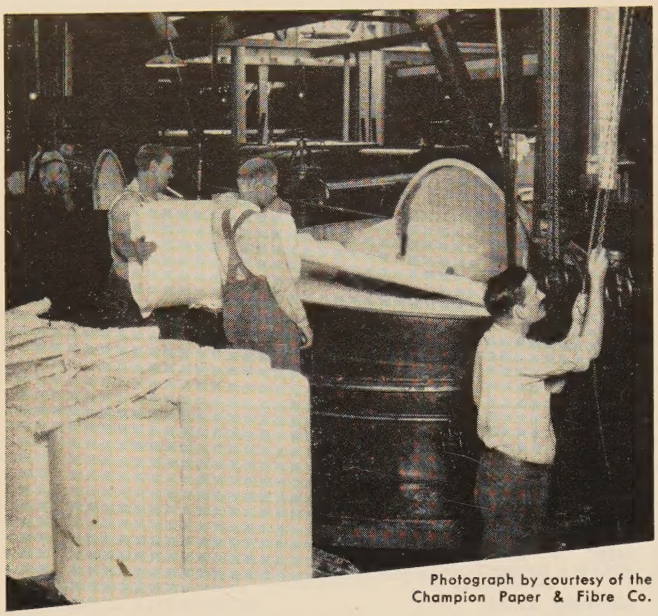
Fourth Testing Conference, Dayton-Biltmore Hotel, Dayton, Ohio, October 6–8, 1954.

Ninth Engineering Conference, Benjamin Franklin Hotel, Philadelphia, Pa., October 18–21, 1954.

Fibrous Agricultural Residues Conference, Northern Regional Research Laboratory, Peoria, Ill., November 8–9, 1954.

Corrugated Containers Conference, DeSoto Hotel, Savannah, Ga., November 17–19, 1954.

Annual Meeting, Commodore Hotel, New York, N. Y., February 21–24, 1955.



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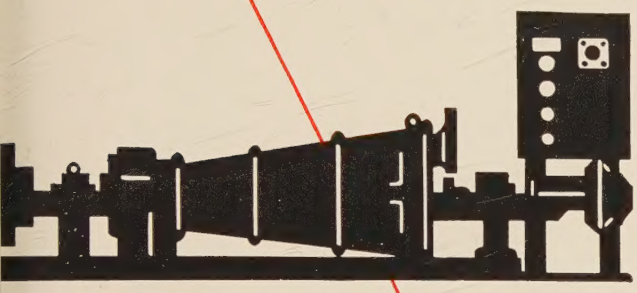

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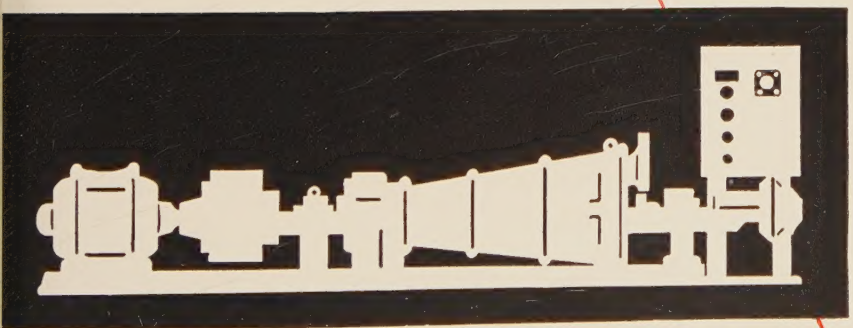

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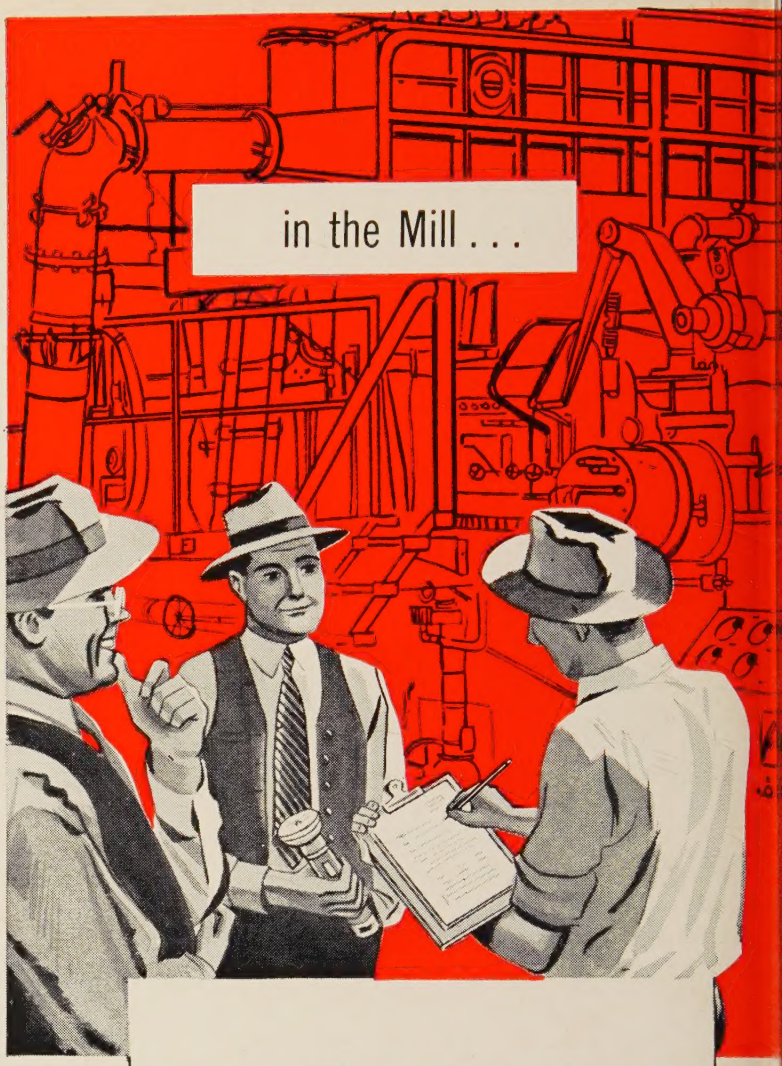

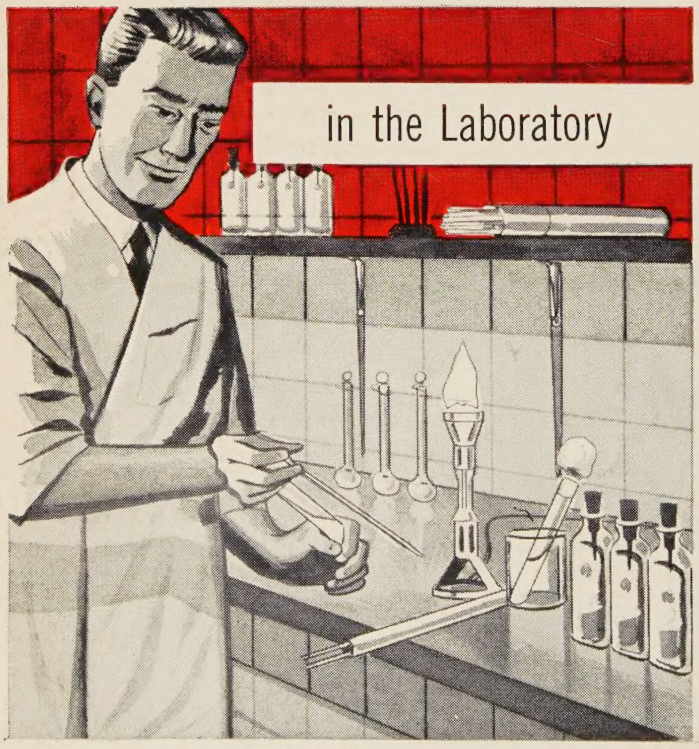

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